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COMPLIMENTS OF
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CALUMET PLANTATION, PARISH ST. MARY, LOUISIANA.

SORGHUM

AS A

Sugar Plant for Lower Louisiana.

RECORD AND DISCUSSION OF FIELD AND LABORATORY EXPERIMENTS, SEASONS OF 1889--90.

By F. E. COOMBS, Chemist.

LOUISVILLE, KY.:
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INTRODUCTION.

Even in Louisiana, the first as well as the most successful of those States in which the manufacture of sugar from tropical cane has been carried on, this industry has not reached the dimensions which are to be desired, because of the serious drawback presented by the short season of actual grinding allowed the sugar planter; for no matter how much cane may be grown, he has on the average scarcely more than two months during which he may harvest it, or else take the risk of working up a portion of the cane without profit.

An important loss is sustained from this long period of idleness, not alone in material damage to machinery and apparatus through rusting, neglect, etc., but in the mere fact of non-use of the costly plant, which thus cheats a large invested capital of its due interest for nine months of each year. These considerations have led many to inquire for means of extending the productive season of the sugarhouse and refinery, and no satisfactory means has been suggested except that of securing a supplemental crop which might ripen in a shorter time than does tropical cane, and so permit the mill to commence operations at an earlier date.

The sugar beet and sorghum cane have both been proposed as auxiliaries to the present cane crop; but an investigation of this subject was made by Mr. W. J. Thompson in 1887, and its result was such that he was led to believe that the beet, although so well established in Europe and of such promise elsewhere in America, would never be adapted to the soil and climate of Southern Louisiana, nor to the agricultural processes and methods of cultivation required upon a cane estate. On the other hand, Mr. Thompson's earliest investigations convinced him that sorghum offered such promise of success as would warrant cultural experiment with this plant, and he accordingly made a careful selection of varieties in the light of the experience which had been gained by Dr. C. A. Crampton and Mr. A. A. Denton at the U. S. Sorghum Experiment Station at Sterling, Kansas. Seed was procured from these gentlemen, and in 1889 was begun in earnest the search for, or

development of, a variety of sorghum suited to the climate and alluvial soil of lower Louisiana. This is believed to be the first systematic work of the sort ever undertaken with this plant by a private individual, Mr. Daniel Thompson, proprietor of the Calumet plantation, having in this case remained its sole patron.

The objects kept in view have been: Study of the cultural methods best adapted to the plant under the conditions presented by the environment, and its acclimatization to these conditions; an ultimate selection of those varieties which experience will have shown to be best adapted to the habitat, after acclimatization and careful comparison of the more promising among them, and to determine whether any of these are promising enough to sanction a continuance of the experiments. For the purpose of such comparison, it was necessary to plant and cultivate alike, and to otherwise insure essentially like conditions in the case of every variety entering the competition; to afterward sample all in like manner, and to secure considerable numbers of juice analyses made upon uniformly drawn average samples taken at intervals throughout the period of maturity; an improvement of each variety, so far as possible, by selection of seed for again planting, from those individuals only which were found to possess desirable qualities in a maximum degree, this requiring separate analyses of the juices from a very large number of individual stalks; incidentally, the study of certain collateral and practical questions which had risen regarding the sorghum plant, such as its stability, variability, tonnage, needs in details of manufacture and the like.

No effort was made to secure an improved plant by other than these four methods: acclimatization, improved culture, selection from among varieties, and propagation from the best individual canes. Hybridization and other methods present great inducement, but neither time nor facilities for them have yet offered at this place.

These experiments have now been prosecuted for two seasons, and so considerable a mass of material has been accumulated that it appears wise it should be co-ordinated, formulated and discussed, for guidance in further experimentation, and for systematic preservation and reference. As a result of past labors, it is now proposed by Mr. W. J. Thompson, under whose direction all the work has been performed, to discard the less promising varieties and to concentrate future effort upon a few which have already been recog-

nized as having such superior merit as to encourage the hope of eventually securing for the tropical cane plantations of Louisiana a profitable supplemental sugar crop.

That the sorghum plant is, in general, adapted to growth in Louisiana, the large fields raised year after year for stock feeding bear sufficient testimony; when grown for this purpose, moreover, it is so carelessly planted and so poorly (when at all) cultivated, that the good crops usually obtained intimate what it may be possible to accomplish with a suitable sugar-producing variety, if given the attention it should properly receive.

That sorghum of the better varieties contains sufficient cane-sugar to make its profitable extraction worth striving for, is shown by the many analyses which have been made upon its juices, and have been published from time to time; and that such extraction may be secured, is believed by many who have convincingly proved their faith by persistent attempts to do so in Kansas and other States, with varying, and it must be granted, not generally with the hoped for success. But the list of failures in endeavors to manufacture sugar commercially from sorghum has had more weight than is just, for it should be considered that the fault lies not entirely with the intrinsic defects of the cane. There have contributed to these failures not only badly constructed apparatus, unskilled labor, delays in erection of factories and ill-chosen location of these with regard to water-supply and transportation, but also the fact that the cane delivered has in many instances been utterly unfit to be worked, owing to improper culture, harvesting too early or too late, or allowing it to lie cut and exposed in the field until practically valueless before hauling to the factory. And it may be said, that not all these attempts have been quite without encouragement to their promoters.

Of the many known varieties of sorghum, some are productive of cane-sugar in large degree, and others in less, or not at all. The sugar-yielding sorts all vary widely in form, size and suitability to different soils and climatic conditions, these qualities being most constant in types which have been longest cultivated. Such differences make it possible to select at the outset the varieties likely to be adapted to a given locality, and by experiment with a number of these to find which are best fitted for growth there. Afterward, by selection of seed from single stalks found by observation and analysis to possess desirable traits of form and growth

and qualities of juice, planting this seed and continuing the selection from the new plants produced, it is almost certain that in course of time a stable variety may be perfected, which will present the valuable characteristics of the original stalk, and the long cultivation of this new variety will tend to make it fixed and permanent.

Experiments in the directions indicated have been continued during 1889 and 1890, as said before, under the direction of Mr. W. J. Thompson; and the following report shows, as briefly as the subject admits, their result.

In the work of 1890 the efficient aid of Mr. W. Y. Kemper, of Glencoe, La., as analyst in the laboratory, made possible a far wider range of experiment and a more extended system of investigation than could be undertaken the previous year, and much credit is due to him.

CULTURAL EXPERIMENTS OF 1889.

In pursuit of these experiments, in 1889, a piece of comparatively new, stiff black land, on which an earlier crop of corn had perished from drouth, was chosen as a convenient site. When the heavy and prolonged rains which followed the drouth sufficiently abated to permit of working the soil, it was replowed, ridged and opened, and the seed was drilled in by hand and covered with the hand-hoe to a uniform depth of one inch. All this was accomplished during the forenoon of June 19th, the rains setting in again the same afternoon. Sixteen plots were made, in rows each distant two hundred feet from the next parallel one, with the same space between adjoining ends. By June 24th, the fifth day from planting, all but three plots had come to a satisfactory stand, and all but two by the seventh day, June 26th. The seed of these two plots failed to germinate almost completely. The rains which recommenced on the afternoon of the day of planting, continuing sixty-three days, *i. e.*, until August 21st, prevented the use of fertilizers, and even allowed no cultivation except a careful hoeing and the turning of a few furrows to the rows, which was done on July 20th, the twenty-sixth day from seeding, the canes at this time averaging one foot in height.

After August 21st, however, the weather changed and continued drouthy until the end of the growing season, except for one heavy rain on September 25th, the ninety-eighth day. On

November 19th, finally, the one hundred and fifty-third day, a severe freeze destroyed all the canes then standing and put an end to the season's work.

The sixteen plots were of the varieties and description given below. The seed from which the Calumet sorghum was raised this year (1889) was obtained from Sterling, Kansas; and to establish a standard for judging our own work, analyses are given for each variety which were made at Sterling in 1888, these being, in most cases, analyses of the *parent plot*, but in several instances where this could not be assured, the best average or single stalk analyses of the *variety* at that station for 1888 is given instead, and the fact is so stated. The serial number of the Sterling plot when known is also specified.

It will be understood that all these analyses are made upon the juice expressed by the small experimental mill. Average analyses are made upon the mixed juice of an arbitrary number of canes selected to represent as nearly as possible the character of the whole plot sampled, and single stalk analyses upon the juice of individual canes chosen from the plot by outward signs as the best in form, size, maturity and the like, and further selected for the laboratory by the Brix spindle test of their juices.

PLOT No. 1. EARLY ORANGE. Planted with seed from Plot No. 84, Sterling, Kansas, 1888, the stock having long been resident in that State. The best average analysis for the parent (Sterling) plot, 1888: Solids, 17.58; Sucrose, 12.82; Purity, 72.92; Glucose, 1.33. Best record for this variety and year at Sterling, a single stalk selected from a large field: Solids, 22.18; Sucrose, 17.05; Purity, 76.87.

Best average analysis of derivate plot, Calumet, 1889, one hundred and thirty days from planting: Solids, 21.30; Sucrose, 16.02; Purity, 75.21; Glucose, 1.95. Best single stalk analysis, Calumet, 1889: Solids, 22.30; Sucrose, 17.37; Purity, 77.89, this on the one hundred and thirty-seventh day from seeding.

This Calumet plot was planted on a ditchbank and thinned, when the plants were about 4 inches high, to a stand of one plant to 3 inches. Seed-heads generally in sight by the sixty-third day from planting; seed beginning to harden on the ninety-first day. Analyses commenced on this plot October 5th, the one hundred and eighth day. Not much lodging, due to wind, was noticed in this plot, though many canes were lost through the effect of "red disease" and the injury from the tropical borer (*Chilo saccharalis*), both of which attacked these canes seriously. Supplemental heads and off-shoots from the base were very common.

PLOT No. 2. EARLY ORANGE. Planted with seed from Plot No. 68, Sterling, Kansas, 1888, the stock having been received there from Louisiana that year. The best average sample analyses for the parent (Sterling) and

derivate (Calumet) plots are: Sterling Plot No. 68, 1888: Solids, 17.90; Sucrose, 12.90: Purity, 72.07; Glucose, 1.13.

Calumet Plot No. 2, 1889: Solids, 21.40; Sucrose, 16.30; Purity, 76.16; Glucose, 2.50, this last analysis on the one hundred and twenty-sixth day. Best single stalk analysis of parent plot, 1888: Solids, 16.31; Sucrose, 14.43; Purity, 88.47. Best single stalk of derivate plot 1889: Solids, 23.50; Sucrose, 18.05; Purity, 76.80; the latter made one hundred and eighteen days after seeding.

The Calumet plot was planted on a ditchbank. A few seed-heads were in sight, and the canes were about 7 feet in height by the sixty-third day. Little lodging was observed, though there was more sprouting than in case of Plot No. 1. Less injury was sustained from borers and disease (the "red disease" mentioned, "Bacillus sorghi" being its reputed cause) than the preceding plot.

PLOT No. 3. LINK'S HYBRID. Seed *probably* from Plot "0," Sterling, Kansas, 1888. Best average analysis of parent plot: Solids, ——; Sucrose, 14.09; Purity, ——. Of derivate plot: Solids, 20.70; Sucrose, 16.44; Purity, 79.42; Glucose, 1.16, one hundred and eleven days after planting. The best single stalk analysis with this *variety* at Sterling, 1888: Solids, ——; Sucrose, 16.51; Purity, ——. The best single stalk analysis of the derivate plot, 1889: Solids, 22.00; Sucrose, 18.26; Purity, 83.00, on the one hundred and eighteenth day.

Plot located on a ditchbank. Seed-heads were forming on the sixty-third day. On the one hundred and seventh day these canes had reached a height of about ten feet, and the seed was already hardening.

Although at Sterling this variety was said to lodge badly, the fault was not apparent here. But slight injury was suffered by it here from disease or from the borer, and this, together with the uniformly high juice analyses obtained, made it one of the favorite varieties of the season.

PLOT No. 4. WHITE INDIA. Planted with seed from Sterling, Kansas; parent plot not certain, but probably No. 69, of 1888, of which plot the best average analysis was: Solids, 17.67; Sucrose, 13.07; Purity, 73.96; Glucose, 1.02. No average analyses could be made on the derivate (1889) plot. The best single stalk analysis of the variety at Sterling in 1888 is not known. That of the derivate plot was: Solids, 22.00; Sucrose, 17.31; Purity, 78.70; Glucose, 1.31, one hundred and twenty days from seeding.

This plot was one not planted on a ditchbank, and may have had poor drainage in consequence. No satisfactory stand was obtained, the seed not germinating well; and the few plants that came were yellow in color and of irregular size, perhaps because too thin on the ground to shade the roots. Sixty-nine days after seeding, these stalks appeared more healthy, were of large diameter and about 7½ to 8 feet tall. On the one hundred and twenty-first day the seed were becoming hard and the lower leaves dying. Lodging was noticed among these canes, few as there were. Large and heavy seed-heads were grown, of the characteristic whiteness. About forty-five canes were obtained from the plot, quite free of disease and borers. Defective germination was observed in this variety at Sterling the year before.

PLOT No. 5. RED LIBERIAN. Planted with seed from Sterling, Kansas, 1888. Parent plot unknown. The best sucrose obtained on an average sample of the variety for that year and station was 14.76 per cent. The only average sample analysis of the derivate plot at Calumet, 1889: Solids, 17.20; Sucrose, 9.87; Purity, 57.38; Glucose, 2.74, one hundred and eleven days after planting. The best sucrose obtained for a single stalk of this variety at Sterling, 1888, was 17.69 per cent. Best single stalk derivate plot, 1889: Solids, 21.70; Sucrose, 15.13; Purity, 68.77; this analyzed on the one hundred and thirty-ninth day. The plot was not on a ditchbank. Seed-heads were all in sight, and just darkening on the ninety-first day. One supplemental head on each cane; not much injury from borers, but a great deal from the "red disease" was suffered by this plot, and very little lodging occurred, although the canes were quite slender.

PLOT No. 6. LATE ORANGE. Planted with seed from Plot No. 89, Sterling, Kansas, 1888. Maximum average analysis for that plot and year: Solids, 17.99; Sucrose, 12.73; Purity, 70.76; Glucose, 2.32. Maximum average analysis of derivate plot, 1889: Solids, 20.70; Sucrose, 16.44; Purity, 79.42; Glucose, 2.39, on the one hundred and twenty-sixth day. The best single stalk secured from the parent plot (No. 89) was a variation from the type, analyzing: Solids, 18.78; Sucrose, 13.64; Purity, 72.63; Glucose, 2.94. Best single stalk analysis of derivate plot, 1889: Solids, 22.80; Sucrose, 18.11; Purity, 79.42; Glucose, 1.17, on the one hundred and thirty-first day.

This was another of the plots not on ditchbanks, and thought to have suffered for lack of drainage. Seed-heads began to show about sixty-seven days after planting, coming earliest on the canes at one end of the plot, which were taller there than elsewhere. Some lodging was caused by wind, but comparatively little injury was suffered from borers or disease.

PLOT No. 7. HONDURAS. Planted with seed from Plot No. 64, Sterling, Kansas, 1888. Best average analysis of parent plot, 1888: Solids, 15.54; Sucrose, 9.54; Purity, 61.39; Glucose, 3.24. Of derivate plot, 1889: Solids, 13.50; Sucrose, 7.45; Purity, 55.18; Glucose, 3.95, this being the only average sample cut from the Calumet plot, and taken on the one hundred and eleventh day. Best single stalk analysis of parent plot is not known. A cane from a "variation" plot of Honduras, at Sterling, 1888, gave: Solids, 20.00; Sucrose, 14.90; Purity, 74.50; Glucose, 1.02. Best single stalk of derivate plot, 1889: Solids, 16.40; Sucrose, 10.68; Purity, 65.12, on the one hundred and thirty-second day.

Planted on a ditchbank. On the sixty-third day from seeding, this plot was irregular and of sickly color, though large in stalk, and no signs of heading were apparent; many roots had sprung from the joints near the ground. On the ninety-first day this plot had become one of the best in size of canes, which were quite thick on the row, and averaged 11 to 12 feet tall, with seed-heads just darkening. This plot was perhaps the latest maturing of all, and was cut down by the frost of November 19th, the one hundred and fifty-third day from its planting, and before maturity was reached. Borers damaged these canes a little, and they were much diseased.

PLOT No. 8. IMPROVED ORANGE. Planted with seed from Sterling, Kansas, 1888. The parent plot is unknown, and no analyses of the variety at Sterling for that year are available; the statement was furnished with the seed, however, that the variety attains "15.00 per cent. sucrose."

Best average analysis of derivate plot, 1889: Solids, 19.20; Sucrose, 14.81; Purity, 77.14; Glucose, 2.16, on the one hundred and thirteenth day. Best single stalk analysis of derivate plot, 1889: Solids, 21.60; Sucrose, 17.10; Purity, 79.12; Glucose, 1.99, on the one hundred and thirteenth day.

Planted on a ditchbank. On the sixty-ninth day nearly all these canes showed seed-heads, were about 8 feet in height and fairly uniform in size, though of pale foliage. Seed were turning hard by the ninety-first day.

This plot was not very successful in the field; the canes were quite slender and badly injured by the borer, only one other plot having suffered more from this cause. Lodging was not noticeable, but the canes bore many supplemental heads, often two to the stalk.

PLOT No. 9. GOOSENECK. Planted with seed believed to be from Plot No. 76, Sterling, Kansas, 1888. Best average analysis of that plot (after frosts and before maturity): Solids, 18.00; Sucrose, 11.78; Purity, 65.44; Glucose, 2.60. The only average analysis of the derivate plot, 1889: Solids, 17.00; Sucrose, 11.74; Purity, 69.06; Glucose, 3.11, on the one hundred and eleventh day. No single stalk analysis of this variety at Sterling can be had. The best single stalk of the derivate plot, 1889, was: Solids, 19.90; Sucrose, 15.58; Purity, 78.29; Glucose, 1.71; this analyzed on the one hundred and thirty-second day from seeding.

Planted on a ditchbank. By the sixty-ninth day the canes of this plot were about 8 feet tall, of good color and of quite large diameter, but not thick on the row. One of the worst "suckered" plots at that date, its seed-heads just coming into view. There was no regularity in the ripening of the seed, and from the violent variations of form among them it seemed certain that these canes were derived from crossed seed. Many stalks resembling Orange and Amber types were noticed.

The characteristic pendent seed-head of this variety seems an objection, as a possible source of inconvenience in handling in the field and at the cane-carrier.

PLOT No. 10. (STERLING PLOT No. 51, OF 1888.) Planted with seed from Plot No. 51, Sterling, 1888, at which station the variety held a good record for purity of juice, the best average sample being, for 1888: Solids, 17.77; Sucrose, 12.80; Purity, 72.03; Glucose, 2.27. The only average analysis for the derivate plot, 1889: Solids, 14.20; Sucrose, 8.17; Purity, 57.53; Glucose, 2.96, one hundred and eleven days from planting. The best single stalk analysis at Sterling for 1888 can not be given; that for the derivate (Calumet) plot, 1889, was: Solids, 20.70; Sucrose, 15.67; Purity, 75.70, on the one hundred and thirty-seventh day.

Planted on a ditchbank, but still seemed to lack proper drainage. Seed-heads were irregular in time of appearing, and the canes not uniform in development. On the sixty-ninth day the majority of these canes were but 5 feet in height, of sickly color (this especially marked at one

end of the row), and without seed-heads, while a few stalks were nearly 11 feet tall and with heads well out. More uniformity in height and general appearance was gained by the ninety-first day, but the plot was the yellowest of any, though handsome otherwise. No evidences of crossing or impurity of stock were detected. The plot continued slow in growth, and fell behind toward the last, having only fairly thick canes of but average (8 feet) height. Not much lodging was observed, but a great deal of suckering from about the roots.

PLOT No. 11. (**STERLING PLOT No. 36, OF 1888.**) Planted with seed from Sterling Plot No. 36, of 1888. Best average analysis obtained with canes of the parent plot, 1888: Solids, 15.32; Sucrose, 10.29; Purity, 67.17; Glucose, 0.63. The only average analysis of derivate plot, 1889: Solids, 13.30; Sucrose, 7.85; Purity, 59.02; Glucose, 2.96, on the one hundred and eleventh day.

Best single stalk analysis of parent plot unknown. That of the derivate plot, 1889: Solids, 18.60; Sucrose, 12.73; Purity, 68.87; Glucose, 1.97, made on the one hundred and thirty-third day.

Not planted on a ditchbank. The plants were injured while very small by "bud worms." Seed-heads appeared, irregularly, about seventy-eight days after planting. On the one hundred and nineteenth day the plot was apparently unhealthy and showed evidences of mixed breeding. Slim canes, not nearly as mature as most other plots at the same date, and very little lodged by winds. Borers were very numerous in these canes, and some stalks were badly diseased and reddened. This variety was said to produce the largest canes grown at Sterling in 1888, but this plot did not succeed here. Maturity was never reached.

PLOT No. 11 P. (**STERLING PLOT No. 36, OF 1888.**) An exact duplicate, as to seed, of the preceding plot, planted at the lower end of the same row, not so close to the ditchbank. Much more advanced than its duplicate, having seed-heads out by the sixty-ninth day, at this date being some 9½ feet tall and very handsome. On the one hundred and twenty-ninth day, the canes, though still quite erect, were sprouting from every joint and rooting badly from several of the lower nodes. These were the largest canes grown at Calumet in 1889, but never matured. The best single stalk of Plot 11 P was analyzed on the one hundred and ninth day, giving: Solids, 13.20; Sucrose, 6.08; Purity, 46.06; Glucose, 2.52. After this day's analysis no further work was done with the plot, others then at maturity claiming all the time which could be given to them.

PLOT No. 12. (**STERLING PLOT No. 15, OF 1888, SORGHUM BICOLOR.**) Planted with seed from Plot No. 15, Sterling, 1888. Best average analysis of parent plot, 1888: Solids, 18.64; Sucrose, 12.87; Purity, 69.05; Glucose, 0.65. [The derivate Plot No. 12 was wholly of small, slender canes, badly lodged, sprouted and infested with borers. Having so many varieties of vastly better promise, no seed selection was attempted from this, no analyses were made, and the variety was omitted from the list for 1890 planting.]

PLOT No. 13. (**STERLING PLOT No. 14, OF 1888.**) Planted with seed from Plot No. 14, Sterling, 1888. Best average analysis of parent plot,

1888: Solids, 18.60; Sucrose, 13.84; Purity, 74.41; Glucose, 0.55, one hundred and sixty-three days after planting. The only average analysis of derivate plot, 1889: Solids, 17.20; Sucrose, 10.11; Purity, 58.37; Glucose, 3.12, one hundred and eleventh day.

The best single stalk of the parent plot is not known. Best single stalk of the derivate plot, 1889: Solids, 19.60; Sucrose, 14.69; Purity, 75.06, on the one hundred and twenty-fifth day.

Plot located on a ditchbank. Seed-heads had appeared by the sixty-third day, when the canes were at an average height of 8 feet, very handsome in color, but too much inclined to sprouting. Seed were hardening by the ninety-first day. This plot suffered from the attacks of the cane-borer, and lodged notably.

PLOT No. 13 P. (STERLING PLOT No. 14, OF 1888.) An exact duplicate of Plot No. 13, preceding. No average samples were drawn from this plot, and but two single stalks were analyzed, the better of these, cut on its one hundred and eighth day, giving: Solids, 17.70; Sucrose, 12.48; Purity, 70.51. This plot was so like its duplicate in all respects that no special description is needed.

PLOT No. 14. WHITE INDIA. Planted with seed from Plot No. 70, Sterling, Kansas, 1888. Best average analysis of parent plot, 1888: Solids, 19.05; Sucrose, 13.26; Purity, 69.61; Glucose, 1.61. There were no average samples drawn from the derivate plot. Best single stalk of the parent plot can not be given; that of the derivate plot, 1889: Solids, 19.00; Sucrose, 13.85; Purity, 72.90, on the one hundred and twenty-second day from planting. Planted on a ditchbank. Germination tardy, irregular and weak, few plants being obtained. In growth and characteristics like Calumet Plot No. 4 in all respects.

By comparing the average sample analyses of the foregoing Calumet (or "derivate") plots with those of the corresponding Sterling (or "parent") plots, we find that many varieties have fallen off from their Kansas record for 1888. Those varieties, the average analysis of which here did not equal that of the parent plot or variety at Sterling the year before, were, Red Liberian, Calumet Plots Nos. 10, 11, 11 P, 13 and 13 P. Honduras failed also to do as well here as at Sterling, since it never reached maturity, and as other causes combined to place it at a disadvantage: and in greater or less degree, this is also true of other varieties. Both derivate plots of Early Orange, the plot of Link's Hybrid, and that of Late Orange, were superior, in analysis at least, to their parent plots. Gooseneck was nearly the same in sucrose content here in 1889 as at Sterling the former season. Plots Nos. 4, 8 and 12 can not be compared with their parent plots, for want of sufficient data. On the whole, it is considered that the result of the work of 1889 was satisfactory, if only as furnishing evidence that

sorghum would grow and produce a reasonable percentage of cane sugar in this climate and upon these lands.

Briefly stated, the weather during which the sorghum was grown was very wet at the time of and for the few weeks succeeding germination, and exceedingly dry for the latter half of the growing period, and while seed was forming—presumably favorable conditions—and but for the large extent of damage by borers, faulty drainage and disease, a far better showing would doubtless have been made.

As a result of this work, it was decided to continue culture experiments in 1890 with all the varieties tried in 1889, with the exception of Honduras, which was considered of too slow growth to suit the purpose, and Sterling Plot No. 15, 1888 (Calumet Plot No. 12), which was too small a variety.

CULTURAL EXPERIMENTS OF 1890.

During the season of 1890 these experiments have been continued in substantially the same manner as in 1889, Honduras and Sterling Plot No. 15 having been discontinued, however, and the addition made of several varieties new to Calumet, thus increasing the number of varieties from twelve to sixteen. An important innovation was made, in planting duplicates of certain varieties at separate dates with the intention of prolonging the seed-selection work while gaining as well an opportunity to watch the influence of varying weather, which it was thought might afford very different growth conditions to each planting. It was further hoped that by thus planting portions of seed at proper intervals, it might be demonstrated that crops could be grown by this method which would afford mature canes for a much longer period of manufacture than could be possible by any other means. The first and chief planting was to have been made in the same locality occupied by the plots of 1889, but this being exposed to inundation from the Mississippi river, which threatened at the time, it was abandoned for another and higher part of the plantation. Here, on March 24th, the Messrs. Thompson personally superintended the seeding of nineteen plots, which were covered to a depth of one inch by hand-hoe. At this date the land not reserved for the experiments was in corn, which had just appeared above ground, and amidst this the sorghum was planted in single rows. Ditch-

banks were used for the latter, three rows along each, separated at the ends by about fifty feet and from parallel rows by two hundred feet, as in the former season. Drouthy weather prevailed at this time, the soil being in good tilth, but unduly dry for rapid germination. On March 29th, however, the fifth day following, all the plots had come to a "stand," with few exceptions. By April 1st, the eighth day, the stand was entirely satisfactory except in two plots, which for some unknown cause proved complete failures. April 12th, the nineteenth day from planting, when suffering from drouth, the soil was hoed lightly and the canes thinned, leaving one plant to every three inches. Until the 21st of April, twenty-eighth day from planting, no rain fell, when three days of showery weather were very beneficial. May 13th, *i. e.*, on its fiftieth day, the first planting was plowed and laid by, all suckers and weak plants being destroyed at the same time. No fertilizers were used on this series: the minimum degree of attention bestowed on this, as on subsequent plantings, was due to conflict with threatened overflow on the levees.

The first planting consisted of the following varieties, those which were tried on Calumet in 1889 retaining the plot numbers given them that year:

PLOT No. 1. EARLY ORANGE.

Planted with seed from five "star" heads selected from Calumet Plot No. 1, 1889. Average of the analyses of these parent canes: Solids, 20.60; Sucrose, 16.36; Purity, 79.41. Best average analysis of parent plot, 1889; Solids, 21.30; Sucrose, 16.02; Purity, 75.21; Glucose, 1.95; Non-sugar, 3.33; this on the one hundred and thirtieth day. Best average analysis of derivate plot, 1890: Solids, 19.98; Sucrose, 15.55; Purity, 77.82; Glucose, 1.11; Non-sugar, 3.32, on the one hundred and twentieth day. Best single stalk, parent plot, 1889: Solids, 22.30; Sucrose, 17.37; Purity, 77.89, on the one hundred and thirty-seventh day. Best single stalk, derivate plot, 1890: Solids, 20.31; Sucrose, 15.90; Purity, 78.29, on the one hundred and twenty-second day.

Seed-heads appeared about seventy-six days after seeding, the canes being 6½ feet tall, and seed were hardening by the one hundred and twentieth day, when the canes were about 9 feet high. Wet weather seriously damaged the seed of these canes, causing it to sprout and grow. Tillers and supplemental arrows were very numerous, especially toward the end of growth, and lodging was a noticeable fault. A few of these canes were diseased, and all were slenderer than those raised in the parent plot of 1889.

PLOT No. 2. EARLY ORANGE.

Planted with seed of nine star-heads from Calumet Plot No. 2, of 1889. Average of analyses of these: Solids, 20.70; Sucrose, 16.24;

Purity, 78.45. Best average analysis of parent plot, 1889: Solids, 21.40; Sucrose, 16.30; Purity, 76.16; Glucose, 2.50; Non-sugar, 2.60, on the one hundred and twenty-sixth day. That of derivate plot, 1890: Solids, 19.07; Sucrose, 14.65; Purity, 76.82; Glucose, 1.80; Non-sugar, 2.62, one hundred and seventeen days after planting. Best single stalk of parent plot, 1889: Solids, 23.50; Sucrose, 18.05; Purity, 76.80, on the one hundred and seventeenth day. Best single stalk from derivate plot, 1890: Solids, 20.35; Sucrose, 16.05; Purity, 78.87, on the one hundred and twenty-ninth day.

Nearly all seed-heads were out by the eighty-first day, when the canes averaged about 7½ feet in height. On the one hundred and twentieth day the seed were becoming brittle, with the canes at an average height of 8 feet. Sprouting of seed, tillering, etc., were very much the same as in the preceding Plot No. 1.

PLOT No. 3. LINK'S HYBRID. Planted with seed from eleven seed-heads selected from Calumet Plot No. 3, of 1889. Mean analysis of these eleven cases: Solids, 21.30; Sucrose, 17.32; Purity, 81.31. Best average analysis of parent plot, 1889: Solids, 20.70; Sucrose, 16.44; Purity, 79.42; Glucose, 1.16; Non-sugar, 3.10, on the one hundred and eleventh day of growth. Best average analysis of derivate plot, 1890: Solids, 20.42; Sucrose, 15.80; Purity, 77.45; Glucose, 0.56; Non-sugar, 3.34, on the one hundred and nineteenth day. Best single stalk of parent plot, 1889: Solids, 22.00; Sucrose, 18.26; Purity, 83.00, on the one hundred and eighteenth day from seeding. Of derivate plot, 1890: Solids, 21.39; Sucrose, 16.70; Purity, 78.07, on the one hundred and twenty-first day.

Seed-heads came into view about the seventy-eighth day, the canes then irregular in height, but averaging about 7 feet. Seed were becoming brittle about one hundred and twenty days after planting, but in this, as in most other plots, seed were found on parts of the same as well as on different heads, ranging from green and soft to quite hard and mature. At this date the average height of the canes was about 10 feet. One end of the plot, from the outset, was of much greener, larger and quicker maturing canes than the other; this was attributed to variation in the character of the soil, for in a row of corn growing next the sorghum, the same peculiarity was remarked. Like variations are not infrequent in such plots, and often might lead to unwarranted suspicion of the seed used. Much sprouting, tillering, etc., existed among these canes, but their seed resisted the damp weather without germinating, owing perhaps to the loose panicle of this variety, which does not retain moisture as a more compact type will. This is considered one of the most promising varieties here.

PLOT No. 4. WHITE INDIA. Planted with seed from the best seven canes of Calumet Plot No. 4, of 1889. Mean analysis of these: Solids, 20.77; Sucrose, 15.94; Purity, 76.75. No single stalks of the derivate plot were analyzed, but the mean of all the average samples was: Solids, 18.33; Sucrose, 13.28; Purity, 72.45. The parent (1889) plot was grown from seed which did not germinate well, and hence the derivate plot was sown thickly. A perfect stand resulted, but from the canes produced *not one seed* was secured because of a "blight" or fungus disease which ruined

these entirely at an early stage. Many heads appeared to be wholly chaff. The variety has been abandoned, for the present at least, and needs no further mention.

PLOT No. 5. RED LIBERIAN. Planted with seed from two selected heads of Calumet Plot No. 5, of 1889. The derivate plot exhibited so great departure from the type of this variety, and its canes varied so endlessly among themselves, that but one analysis was made upon them, since the following plot was of canes better suited to our work.

PLOT No. 5A. RED LIBERIAN. Planted with seed from a single head, selected from Sterling, Kansas, Plot No. 131, of 1889. This head was received from Dr. C. A. Crampton. The juice of the parent cane analyzed: Solids, 22.56; Sucrose, 16.83; Purity, 74.60; Glucose, 1.34; Non-sugar, 4.39. Best average and single stalk analyses of the parent plot are not at hand. Best average analysis of derivate plot, 1890: Solids, 18.72; Sucrose, 12.80; Purity, 68.38; Glucose, 3.23; Non-sugar, 2.69, on the one hundred and thirty-ninth day of growth. Best single stalk from derivate plot, 1890: Solids, 19.82; Sucrose, 15.00; Purity, 75.68, on the one hundred and thirty-seventh day. The stalk giving this analysis, however, was not at all like the Red Liberian type, and its seed were not retained.

Seed-heads appeared on these canes eighty-one days after planting, when the average height was about 7½ feet, and brittle seed were first noted on the one hundred and twentieth day. More irregularity existed in the plot than was anticipated in the offspring of a single head, and several variations were so much larger and finer in appearance than the rest that their seed were preserved, contrary to the rule of saving from a variety only seed of the best typical canes, it being requisite to maintain *stability* as well as other qualities of a stock. Wet weather and its consequences, sprouting, etc., early ended the work upon this plot, the seed molding and spoiling so that selection became impracticable.

PLOT No. 6. LATE ORANGE. Planted with seed from five star-heads grown in Calumet Plot No. 6, of 1889. Their mean analysis: Solids, 21.72; Sucrose, 17.06; Purity, 78.55. Best average analysis of parent plot, 1889: Solids, 20.70; Sucrose, 16.44; Purity, 79.42 (Glucose not determined), on the one hundred and twenty-sixth day. Best average analysis of the derivate plot, 1890: Solids, 20.68; Sucrose, 16.30; Purity, 78.82; Glucose, 1.41; Non-sugar, 2.97, on the one hundred and twentieth day. Best single stalk of parent plot, 1889: Solids, 22.80; Sucrose, 18.11; Purity, 79.43; Glucose, 1.17; Non-sugar, 3.52, on the one hundred and thirty-first day. Best single stalk of derivate plot, 1890: Solids, 20.92; Sucrose, 16.60; Purity, 79.35; Glucose, 2.19; Non-sugar, 2.13, on the one hundred and twenty-first day.

Seed-heads were for the most part out by the eighty-first day, the canes then averaging 7½ feet in height. Seed were nearly all hard and brittle by the one hundred and twentieth day, and already beginning to germinate from the damp, hot weather; this sprouting was so general that very little of the seed selected from Plot No. 6 was considered reliable. Lodging was a pronounced fault with the plot.

PLOT No. 7. HONDURAS VARIATION. Planted with seed from two heads grown in Plot No. 117, Sterling, Kansas, 1889, that plot having been derived from a single head. Mean analysis of the parent canes: Solids, 22.00; Sucrose, 16.98; Purity, 77.18. Best average and single stalk analyses of parent plot are not yet received. Best average analysis of derivate plot, 1890: Solids, 20.11; Sucrose, 15.55; Purity, 77.32; Glucose, 1.22; Non-sugar, 3.34, on the one hundred and twenty-sixth day. Best single stalk of derivate plot, 1890: Solids, 19.92; Sucrose, 15.35; Purity, 77.05, one hundred and thirty-one days from planting.

Owing to failure in obtaining satisfactory seed from Calumet Plot No. 7, 1889 (Honduras), and a wish to continue experiment with a variety so excellent in point of size and form, this variation (said to be earlier than the type) was substituted, the seed being obtained from the United States Department of Agriculture, through the kindness of Dr. C. A. Crampton.

Nearly all seed-heads were in sight by the eighty-first day, the canes then averaging about 8 feet in height, but much slenderer than ordinary Honduras. Hard seed were noted on the one hundred and twentieth day. In height, diameter and form, these canes were quite irregular, although they were derived from two seed-heads, both selected at Sterling on the same date, and thus presumably equally mature. Less lodged by wind than most plots of the first planting, but equally with them sprouted and tillered. A variety hardly of sufficient merit to warrant its culture another season, as it has been decided to limit future experiment to a minimum number of these.

PLOT No. 8. IMPROVED ORANGE. Planted with seed from five star-heads selected from Calumet Plot No. 8, of 1889. Mean analysis of these: Solids, 21.26; Sucrose, 16.45; Purity, 77.38. Best average analysis of parent plot, 1889: Solids, 19.20; Sucrose, 14.81; Purity, 77.14; Glucose, 2.16; Non-sugar, 2.23, on the one hundred and thirteenth day. Best average analysis of derivate plot, 1890: Solids, 21.22; Sucrose, 16.45; Purity, 77.52; Glucose, 1.48; Non-sugar, 3.29, on the one hundred and thirty-ninth day. Best single stalk of parent plot, 1889: Solids, 21.60; Sucrose, 17.10; Purity, 79.12, on the one hundred and thirteenth day. Best single stalk of derivate plot, 1890: Solids, 24.04; Sucrose, 18.25; Purity, 75.91, on the one hundred and twenty-seventh day.

Seed-heads made their appearance by the eighty-first day, the canes at the time being very slender and but 6½ feet high. By the one hundred and twentieth day the seed were becoming brittle, and the average height of the canes had reached 8 feet, still quite slender, and with many supplemental heads coming out. Few seed-heads were saved from this plot, those which were kept being of doubtful vitality, as this variety was one of the worst in respect to the sprouting of its seed from the wet weather. Rather badly bent and lodged toward the last.

PLOT No. 9. GOOSENECK. Planted with the seed of a single cane selected from Calumet Plot No. 9, of 1889. Owing to the miserable condition of the wind-tangled and slender canes produced in the derivate plot, and their evidently hybridized nature, no analytical work was undertaken with them. The down-turned head of the variety is considered, moreover, a

faulty form, and this drawback is not apparently compensated for by any special merit in other directions, for which reasons nothing further will be attempted with it.

PLOT No. 10. (**STERLING, KAN., PLOT No. 51, OF 1888.**) Planted with seed from the best two canes selected from Calumet Plot No. 10, of 1889. Mean analysis of the two: Solids, 20.50; Sucrose, 15.29; Purity, 74.59. The only average analysis of the parent plot, 1889: Solids, 14.20; Sucrose, 8.17; Purity, 57.53, on the one hundred and eleventh day from planting. Best average analysis of derivate plot, 1890: Solids, 19.42; Sucrose, 14.50; Purity, 74.66; Glucose, 1.23; Non-sugar, 3.69, on the one hundred and forty-ninth day. Best single stalk analysis of parent plot, 1889: Solids, 20.70; Sucrose, 15.67; Purity, 75.70, on the one hundred and thirty-seventh day. Best single stalk of derivate plot, 1890: Solids, 20.38; Sucrose, 15.50; Purity, 76.06, on the one hundred and thirty-third day.

Most of these canes headed out by the seventy-sixth day, being very irregular in height, ranging from 4 to 8 feet, one end of the row having the tallest canes, but all quite slender. Brittle seed were noted on the one hundred and twentieth day, but the heads were below the average in productiveness. Few well-developed canes were raised, and many supplemental heads were formed. Not a satisfactory plot.

PLOT No. 11. (**STERLING, KAN., PLOT No. 36, OF 1888.**) Planted with seed from the best two canes selected from Calumet Plot No. 11, 1889. Mean analysis of the two parent canes, 1889: Solids, 16.60; Sucrose, 12.01; Purity, 71.14. But one average sample was taken from the parent plot, 1889: Solids, 13.30; Sucrose, 7.85; Purity, 59.02; Glucose, 2.96; Non-sugar, 2.49, on the one hundred and eleventh day. Best average analysis of canes from derivate plot, 1890: Solids, 18.27; Sucrose, 11.60; Purity, 63.45; Glucose, 1.99; Non-sugar, 4.68, on the one hundred and fortieth day. Best single stalk analysis of parent plot, 1889: Solids, 18.60; Sucrose, 12.73; Purity, 68.87, on the one hundred and thirty-third day. Best single stalk analysis of derivate plot, 1890: Solids, 18.72; Sucrose, 13.90; Purity, 74.25, on the one hundred and thirty-seventh day.

Heads were very generally in view by the ninety-sixth day, but in size and development the canes were quite irregular. Brittle seed about the one hundred and twentieth day; some very forward canes had, at this date, attained the height of eleven feet. Seed are borne in very loose panicles. Many of the large stocks, when milled, were found to be corky and dry within and furnished but little juice, and this of low polarization. The plot was retrograding before full maturity had been reached, to judge from analyses made at various periods of growth. A variety not much lodged or bent by wind, but prone to sending out offshoots from the joints.

PLOT No. 12. UNDENDEBULE. Planted with seed from the five best heads among a number received from the United States Department of Agriculture. These were grown in Plot No. 254, Sterling, Kansas, 1889. Mean analysis of the five parent stalks, 1889: Solids, 24.44; Sucrose,

19.07; Purity, 78.44. Best average and single stalk analyses of parent plot, 1889, are not at hand. Best average analysis of derivate plot, 1890: Solids, 20.91; Sucrose, 16.25; Purity, 77.71; Glucose, 0.72; Non-sugar, 3.94, on the one hundred and twenty-sixth day. Best single stalk analysis, derivate plot, 1890: Solids, 23.02; Sucrose, 18.10; Purity, 78.63; Glucose, 0.47; Non-sugar, 4.45, on the one hundred and thirty-eighth day from planting.

A variety previously untried on Calumet, and recommended as "Remarkable for its low glucose and high purity;" said, also, to be very free from offshoots.

Heads made their first appearance about the eighty-third day at one end of the row where canes averaged six to seven feet tall, the other end having shorter and more backward plants. The canes of this plot were far the slenderest grown this season, though locality and poor cultivation may be responsible for this, as the row was so close to the edge of the ditchbank that no effective working could be given to the soil on that side. No sprouting except the usual supplemental heads, one to each stalk. Seed were all hard and brittle by the one hundred and thirtieth day, apparently not greatly damaged by the rains, though in many cases the germ was swollen and darkened.

This was the most unsatisfactory of all the 1890 plots, from the agricultural standpoint, though the juices from its canes were of excellent quality.

PLOT No. 13. (STERLING, KAN., PLOT No. 14, OF 1888.) Planted with seed of the best two canes selected from Calumet Plot No. 13, of 1889. Mean analysis of these two canes: Solids, 20.05; Sucrose, 14.63; Purity, 72.97. But one average analysis of parent plot, 1889: Solids, 17.20; Sucrose, 10.11; Purity, 58.37; Glucose, 3.12; Non-sugar, 3.97, on the one hundred and eleventh day. Best average analysis of derivate plot, 1890: Solids, 17.84; Sucrose, 13.05; Purity, 73.15; Glucose, 1.54; Non-sugar, 3.25, on the one hundred and forty-first day. Best single stalk of parent plot, 1890: Solids, 19.60; Sucrose, 14.69; Purity, 75.06, one hundred and twenty-five days after seeding. Best single stalk of derivate plot, 1890: Solids, 20.19; Sucrose, 15.35; Purity, 76.02, on the one hundred and thirty-sixth day.

Heads were just appearing on the seventy-sixth day, while the canes were very uneven in height, and hard seed were found on the one hundred and twentieth day, at which time more uniformity in size had been reached. Seed-heads were of the open type, with few sprays. A large proportion of the seed was spoiled by the wet, sunless weather, and two or more supplemental heads were developed on each stalk. Lodging was considerable.

PLOT No. 14. EARLY ORANGE (STANDARD PLOT). Planted with a portion of the seed originally received from Sterling, Kans., it having been grown there in 1888; it is identical with the seed used for Calumet Plot No. 2, of 1889, and was reserved for planting in 1890. This standard plot, as well as No. 15, Link's Hybrid, was designed to afford means of deciding whether progress was made by one season's selection work. It was thought this might be learned on comparing the standard plot with

the plot of the former year from the same seed, and by the improvement or the reverse noted in the former, obtaining an approximate factor to be added to or subtracted from each derivate plot when comparing it with its parent of 1889; in this manner partially avoiding the error incident upon comparing sorghum grown in seasons of different character.

The abnormal growth induced by extreme wet weather vitiated the experiment however, and its results are not to be relied upon.

Best average analysis of Calumet Plot No. 2, of 1889 (from the same seed): Solids, 21.40; Sucrose, 16.30; Purity, 76.16; Glucose, 2.50; Non-sugar, 2.60, on the one hundred and twenty-sixth day. Best average analysis of the Standard plot, of 1890: Solids, 19.82; Sucrose, 15.20; Purity, 76.69; Glucose, 1.33; Non-sugar, 3.29, on the one hundred and forty-fifth day. Best average analysis of Calumet Plot No. 2, 1890: Solids, 19.07; Sucrose, 14.65; Purity, 76.82; Glucose, 1.80; Non-sugar, 2.62, on the one hundred and seventeenth day.

PLOT No. 15. LINK'S HYBRID (STANDARD PLOT). Planted with part of the seed in Calumet Plot No. 3, of 1889. [No germination took place and no canes were secured. This plot was made with the same object as the preceding, No. 14.]

PLOT No. 16. COLMAN CANE. Planted with seed of two canes selected from Sterling, Kan., Plot No. 293, of 1889. Mean analysis of the two stalks: Solids, 22.96; Sucrose, 18.38; Purity, 80.05. Best average and single stalk analyses of the parent (Sterling) plot are not known. Best average analysis of derivate plot, 1890: Solids, 20.81; Sucrose, 16.35; Purity, 78.57; Glucose, 0.69; Non-sugar, 3.77, on the one hundred and twenty-sixth day. Best single stalk of derivate plot, 1890: Solids, 21.82; Sucrose, 17.05; Purity, 78.14; on the one hundred and thirty-eighth day of growth.

This variety originated at Sterling, being a hybrid of Kansas Orange and Early Amber, grown in Sterling Plot No. 153, of 1888, its first trial on Calumet being in 1890.

Seed-heads appeared very uniformly about seventy-six days after planting, the canes being then very regular in size, of good appearance, and averaging 6½ feet in height, the plot being at this time one of the finest-looking of the first series. Brittle seed were noted on the one hundred and twentieth day, the canes at this date being 7½ feet tall, stocky and excellent in outward form. This was a heavy seed-producing variety here, these not rusting and seldom sprouting in the wet weather so often alluded to; this was considered, in all respects, the best variety of the season.

PLOT No. 17. PLANTER'S FRIEND. Planted with seed of two canes selected from Sterling, Kans., Plot No. 186, of 1889. Mean analysis of these two stalks: Solids, 21.61; Sucrose, 16.08; Purity, 74.41. Best average analysis of parent plot, 1889: Solids, 20.46; Sucrose, 16.41; Purity, 79.22; Glucose, 0.55; Non-sugar, 3.70. Best average analysis of derivate plot, 1890: Solids, 20.05; Sucrose, 15.55; Purity, 77.55; Glucose, 1.08; Non-sugar, 3.42, on the one hundred and forty-first day. Best single stalk analysis of parent plot, 1889: Solids, 22.52; Sucrose, 16.75; Purity,

74.37. Best single stalk of derivate plot, 1890: Solids, 21.62; Sucrose, 17.00; Purity, 78.63, on the one hundred and thirty-seventh day from seeding.

Tried on Calumet for the first time in 1890. Seed-heads appeared irregularly, the first coming about the seventy-sixth day, the canes then uneven in height, ranging from 5 to 8½ feet. Seed had commenced to harden by the one hundred and twenty-first day, the canes at this time varying from 9 to 11 feet tall, some of them slender, but on the whole stocky and handsome, except for numerous offshoots. Panicles large, loose and drooping. Seed resisting damp weather quite well. Save the tendency to sprouting, this was among the best varieties.

PLOT No. 18. UBEHLANA. Planted with seed from Sterling, Kans., Plot No. 34, of 1889, the parent canes being Brix spindle selections, all selected upon full analysis, having been retained at Sterling. Best average analysis of canes from parent plot, Sterling, 1889: Solids, 19.34; Sucrose, 14.07; Purity, 72.75; Glucose, 1.97; Non-sugar, 3.30. Best average analysis of derivate plot, 1890: Solids, 19.15; Sucrose, 14.10; Purity, 73.63; Glucose, 2.14; Non-sugar, 2.91, on the one hundred and forty-first day. Best single stalk of parent plot, Sterling, 1889: Solids, 19.98; Sucrose, 14.81; Purity, 74.12. Best single stalk of derivate plot, 1890: Solids, 19.95; Sucrose, 14.60; Purity, 73.18, on the one hundred and thirty-fourth day after planting.

Seed-heads showed about the ninety-sixth day, the canes averaging 10 feet in height. Hard seed first noted on the one hundred and thirty-third day, the canes at this period being very uniform in development and about 10½ to 11 feet tall. These were the largest canes, in diameter, of the season, bearing seed plentifully in the large, open panicles. Some tillering from the base was observed, but very little other sprouting compared with most varieties. A promising cane in size, form and juice-productiveness, but the quality of the juice was under the average.

PLOT No. 19. LINK'S HYBRID AND WHITE INDIA (Cross). Seed obtained from Sterling, Kans. Small canes, poor juice and badly sprouted and mildewed seed were the characteristic features of the plot. Faults of cultivation and soil may explain the first two, but the last failing is a bad one, and but too strongly suggestive of the usual experience with White India stock in the Calumet experiments. The variety will not be continued.

Comparison of the best average analysis of each of the foregoing varieties in 1890, with the corresponding analysis of 1889, shows marked improvement in quality of juice in the following: Calumet Plot No. 10 (Sterling Plot No. 51, 1888); Calumet Plot No. 13 (Sterling Plot No. 14, 1888); slight advance in case of Calumet Plot No. 1, Early Orange; Plot No. 8, Improved Orange; Plot No. 18, Ubehlana. No material difference exists between analyses of 1889 and 1890 in case of Plot No. 2, Early Orange; Plot No. 6, Late Orange; Plot No. 14, the "standard" plot of Early

Orange. Plot No. 3, Link's Hybrid; Plot No. 4, White India, and Plot No. 17, Planter's Friend, all show decided decline. Several varieties, no analyses of which were made at Calumet, or of which the Sterling analyses are not available, can not, of course, be compared, nor any decision reached as to their improvement or retrogression. A few plots were so close to ditchbanks that one side could not be cultivated. Rain is thought to have so hurried the growth of the canes in many instances, and to have so early produced the various forms of offshoots, that a normal maximum was never attained. Some plots even reached their highest analysis and began to decline before the seed were entirely matured.

The second series or planting of sorghum was made on April 25th, thirty-two days after the first was seeded and in the same location, the land at this date being in good order, but very moist. This planting was of three varieties, each a duplicate of a plot of the earlier series. The following are their descriptions:

PLOT No. 20. EARLY ORANGE. Planted with a reserved portion of the seed used for Calumet Plot No. 2 (which see for derivation, etc.). Best average analysis of this derivate plot, 1890: Solids, 18.75; Sucrose, 14.55; Purity, 77.60; Glucose, 2.41; Non-sugar, 1.79, on the one hundred and ninth day. Best single stalk analysis derivate plot, 1890: Solids, 20.42; Sucrose, 15.85; Purity, 77.62, on the one hundred and twenty-third day.

The seed from which this plot grew, although badly weevil-eaten, came up finely and gave a perfect stand. The surrounding crop (corn) was high at the time this (second) series of plots was seeded, and the young sorghum was shaded by it rather too much. This row also suffered from want of cultivation on the side next the ditchbank. Seed-heads had formed on the sixty-fourth day, the canes averaging five feet tall, but slender and uneven in development. Hard and brittle seed were noted on the one hundred and twelfth day. These canes were slenderer than those of Plots 1, 2 and 14, which were of the same variety. The seed did not sprout on the heads, but gained a peculiar "bleached" look. Wind bent the stalks greatly, and on the whole the plot was not considered a success.

PLOT No. 21. LINK'S HYBRID. Planted with a portion of seed reserved from that used for Calumet Plot No. 3, 1890. Best average sample of this derivate plot, 1890: Solids, 19.92; Sucrose, 14.60; Purity, 73.29; Glucose, 0.94; Non-sugar, 4.83, on the one hundred and nineteenth day from seeding. Best single stalk of this derivate plot, 1890: Solids, 19.85; Sucrose, 16.00; Purity, 80.60, on the one hundred and thirtieth day.

Condition of land, shade, etc., as in case of plot No. 20, preceding. Seed-heads formed by the sixty-fourth day, the canes being then quite

uniform in development and ranging in height from 6½ to 7 feet. Hard seed were found on the one hundred and twelfth day, the canes at this time standing some 11 feet tall, with many supplemental heads and other offshoots, although the foliage was yet quite green. Many canes were broken by the wind and lost, and lodging was frequent from the same cause.

The canes of this plot were of fair diameter, larger than those of the duplicate plot No. 3, of the first series, and were of better size and general appearance than plots 20 and 22. But few perfect seed were formed on the heads of this plot, and many of these were lost through rust and blight, though none sprouted.

PLOT No. 22. UNDENDEBULE. (For derivation, etc., see Calumet Plot No. 12, 1890, of which this is a duplicate.) Best average analysis of this plot, 1890: Solids, 21.52; Sucrose, 16.60; Purity, 77.14; Glucose, 0.69; Non-sugar, 4.23, on the one hundred and nineteenth day. Best single stalk analysis of this plot, 1890: Solids, 20.79; Sucrose, 17.60; Purity, 84.65, on the one hundred and twenty-third day after planting.

The stand in this plot was defective, and many plants were lost while quite small through the attacks of a gray worm about three-quarters of an inch long, which entered the stalk below ground and burrowed upward through it. The canes began heading out by the sixty-fourth day, but this only among the larger ones, great irregularity of development existing. Seed had begun to harden on the one hundred and twelfth day, but with great variation in this respect in different parts of the row.

The plot, although of comparatively slender canes, was a vast improvement upon its duplicate of the earlier planting in this; in the laboratory, analyses of these stalks ranked among the highest in Sucrose and in Purity.

Heavy rains and work on the levees in face of threatened floods continued to prevent proper attention being paid to the sorghum experiments until May 12th. On this and the following day, the first and second plantings, now very foul with grass from the enforced neglect, were hoed, the second planting having at this date reached its seventeenth day, with a height of about three inches; its stand then appearing very satisfactory. The second series was planted very nearly at the date when it would be advisable to seed a field for the mill, and its suffering from the unfavorable weather it encountered, while in some respects not so great as that of the first and third series, was still serious and sufficient to render the result disappointing.

Comparing the average analyses of the second series with those of the parent plots of 1889, Early Orange (No. 20) and Link's Hybrid (No. 21) are found to have fallen off. The best average

analysis of the parent (Sterling) plot of Undendebule, of 1889, is not known, and no comparison can be had.

By contrasting the plots of the second series with their duplicates of the first planting (of the same season, 1890), Link's Hybrid is seen to have given a lower analysis on the best average sample in case of Plot No. 21. Early Orange and Undendebule of the second series exhibit no very marked differences between the best average analyses secured with them and with their duplicates of the earlier planting.

The third planting, made May 17th, and comprising plots of four varieties, was given special care, as the seed in the case of each was derived from a single cane which had shown the highest juice analysis for a single stalk of the variety the season preceding. A place was found for these plots near the plantation residence in a garden which had never been manured. The soil was deeply spaded and thrown up into beds, in which the seed was sown by hand in drills. This locality was chosen as a place safer from the incursions of men and stock than the fields, and in this respect it proved satisfactory, although it was found otherwise objectionable. The plots from single seed-heads were Colman Cane, Early Orange, Link's Hybrid and Late Orange. In addition to those named, three special plots were made a few days later. One of these, Plot No. 23, was of a variety from India, Alapore Jowar, its first trial in America being this season (1890). This plot was planted near the first four in the garden referred to. The two remaining, Nos. 24 and 25, were placed in the field with the plots of the second series. The necessary thinning was given these plots on June 2d. While the plots in the garden were very young, insects became so numerous among them that an application of Paris green was made, but this, while it killed the insects, also destroyed nearly all the foliage, and from the effects of this loss of their leaves the plants never seemed to fully recover. Plots "D" (Late Orange) and No. 23 (Alapore Jowar) were further injured by the shade of several large live-oaks near them and did not grow well.

From single heads were derived the following:

PLOT "A." COLMAN CANE. The original unpedigreed seed, from a single head, was planted at Sterling, Kan., in Plot No. 153, of 1888. The best single stalk selected from that plot gave juice analysis: Solids, 22.50;

Sucrose, 17.18; Purity, 76.35; Glucose, 0.58; Non-sugar, 4.74, on the one hundred and forty-fourth day from planting, this being Serial No. 652, of Sterling, 1888. The seed of the foregoing stalk, planted at Sterling as Plot No. 293, of 1889, afforded as its best single cane one with the following analysis (Serial No. 13,103): Solids, ——; Sucrose, 20.72; Purity, ——; Glucose, ——; Non-sugar, ——, on the one hundred and fifty-fourth day of growth. Of its seed-head, No. 13,103, one-half was sent to Calumet by Mr. A. A. Denton, and there planted as Plot "A," 1890. The canes of this plot were all analyzed, one by one, the mean analysis of the whole number (96) being: Solids, 19.91; Sucrose, 15.12; Purity, 75.94. The best single stalk secured from Plot "A," 1890: Solids, 22.68; Sucrose, 17.85; Purity, 78.71; Glucose, 0.53; Non-sugar, 4.30, on the one hundred and seventh day of growth.

Seed-heads appeared by the sixty-seventh day, the canes at that date being irregular in height, ranging from 6½ to 9½ feet. When seed had begun to harden, about the one hundred and third day, great uniformity had been gained, the canes being stocky, erect and handsome. Very few seed were lost from sprouting, and wind did not appreciably affect the plot, which was the most successful one in every way of the third series.

PLOT "B." EARLY ORANGE. Planted with seed from the best single stalk selected from Calumet Plot No. 2, of 1889. The analysis of the stalk furnishing this seed was: Solids, 23.50; Sucrose, 18.05; Purity, 76.80; Glucose, 1.42; Non-sugar, 4.03, on the one hundred and seventeenth day from planting. Because of the small size of many canes of this plot and the damaged (sprouted) seed, the original intention of analyzing each individual stalk could not be carried out, but every healthy cane was separately analyzed, and when the number of these was exhausted, the remaining one hundred were cut, milled and the mixed juice analyzed as an average sample. The mean of all the analyses of the plot (made on one hundred and sixty-eight canes in all) was: Solids, 13.95; Sucrose, 9.32; Purity, 66.81. Best single stalk analyzed in Plot "B:" Solids, 20.28; Sucrose, 15.35; Purity, 75.69; Glucose, 0.59; Non-sugar, 4.34, on the one hundred and seventh day of growth. The analysis of the large average sample: Solids, 12.76; Sucrose, 8.00; Purity, 62.69; Glucose, 1.43; Non-sugar, 3.33, on the one hundred and twenty-second day.

Seed-heads were nearly all in sight by the sixty-seventh day, the canes being at an average height of 8 feet, but very un-uniform. By the one hundred and third day the seed were almost all hard. The canes of this plot were of better size than those in the other plots of Early Orange of this year, such as Nos. 1, 2, 14 and 20, but were prostrated by the wind and lodged badly. Much seed was rendered worthless through sprouting.

PLOT "C." LINK'S HYBRID. Planted with seed of the best single cane selected from Calumet Plot No. 3, of 1889, the juice of the parent cane having given upon analysis: Solids, 22.00; Sucrose, 18.26; Purity, 83.00; Glucose, 1.47; Non-sugar, 2.27, on its one hundred and eighteenth day. Sixty-five single stalk analyses were made upon canes of this derivate plot, and when all that were fit for seed selection had been used, the remaining 72 stalks were cut and analyzed as an average sample, the mean analysis of

the whole number (136) being: Solids, 16.10; Sucrose, 12.01; Purity, 74.59. The best single stalk analysis of this plot was: Solids, 19.48; Sucrose, 15.60; Purity, 78.54; Glucose, 0.36; Non-sugar, 3.52, on the one hundred and ninth day. The large average sample, 72 canes cut on the one hundred and twenty-fourth day, furnished a juice analysis of: Solids, 15.08; Sucrose, 11.25; Purity, 74.60; Glucose, 0.33; Non-sugar, 3.50.

Seed-heads were out by the sixty-seventh day, the canes then being quite green and vigorous, erect and appearing uniform in all respects, averaging 10 feet tall. By the one hundred and third day the seed were nearly all hard, without marked increase in height of the canes. A good stand was secured in this plot, and quite handsome canes until the long rains had spoiled them. Not many seed were formed on the heads, but these remained sound. Many supplemental heads and other offshoots developed.

PLOT "D." LATE ORANGE. Planted with seed of the best single cane selected from Calumet Plot No. 6, of 1889, the juice of the parent cane showing upon analysis: Solids, 22.80; Sucrose, 18.11; Purity, 79.42; Glucose, 1.17; Non-sugar, 3.52, on the one hundred and thirty-first day of growth. But eight single stalk analyses of this derivate plot could be made: The one hundred and thirty-four canes remaining after these (and a small average sample) were cut, were divided and analyzed as two samples. Mean of all analyses made upon the plot (comprising one hundred and forty-seven canes): Solids, 12.05; Sucrose, 7.70; Purity, 63.90. The largest of the average samples analyzed (comprising one hundred and sixteen canes), cut on the one hundred and nineteenth day, gave: Solids, 11.94; Sucrose, 7.65; Purity, 64.15; Glucose, 2.18; Non-sugar, 2.11. Best single stalk analysis of Plot "D:" Solids, 14.58; Sucrose, 10.20; Purity, 69.96; Glucose, 1.85; Non-sugar, 2.53, on the one hundred and ninth day.

The canes of this plot, though uniform in all regards, were very slender and inferior. On the sixty-seventh day, when the mean height was about 7 feet, all the seed-heads had appeared, and a few were beginning to darken in color. About the ninety-fifth day the seed were hard and brittle.

This was the worst situated of the four lettered plots, being not only worst-shaded by the live-oaks, but located, besides, upon a narrow belt of stiff clay, which traversed the garden, intersecting a large part of this row. These canes were not so badly wind-wrecked as those of the Early Orange plot, "B," though much bent and lodged.

Of the four plots just described, "A" (Colman Cane) was farthest from the oaks, and did not materially suffer from the influence of their shade. It was also located in a portion of the garden affording soil of moderately loose texture, its character becoming stiffer and more clayey as the other plots, "B," "C" and "D," were approached.

At the ends of each row (where drainage was best) grew the

largest and finest-looking canes, and the plots were progressively of handsomer and better plants as they were further from the shade and clayey land.

As these four plots were in a portion of the garden upon which no fertilizer had ever been used, tankage was applied (equivalent in amount to 450 pounds per acre) on the twenty-eighth day after planting, thorough spading having been given these plots a day or two in advance. The wisdom of this fertilization was afterward questioned.

By comparison of analyses, the best single cane of each of the four plots is seen to be far inferior to the parent cane from which each was derived. Colman Cane, of the first planting, Plot No. 16, did not furnish so good a single-stalk analysis as did Plot "A." "B" (Early Orange) and "C" (Link's Hybrid) fall not very far behind the plots of these varieties of the second series, but compare much less favorably with those of the first planting. Plot "D" (Late Orange) gave results which have no comparative value, as its normal growth was prevented, by shade and other influences mentioned, to an extreme degree. On the whole, no marked improvement was observed in these four, due to their derivation from single-selected heads, excepting as to uniformity, which was very marked in "A" and quite noticeable in "B" and "C" [the irregularity of size existing in Plot "B" at an early period disappeared at a later stage].

The three "special" plots mentioned a few pages back were the following, all of them planted with seed sent by Mr. A. A. Denton, of Sterling, Kan.:

PLOT No. 23. ALAPORE JOWAR. Planted with seed from Sterling, Kan., the variety described as one from which sugar has been habitually made by primitive processes in India. Previously to 1890 the variety has never been tried in America, and no reliable records of it are to be had.

This seed was planted near Plots "A," "B," "C," "D," but in a part of the garden even worse shaded. Few canes were secured and fewer could be analyzed because of their very small size. The highest single stalk analysis was: Solids, 17.88; Sucrose, 12.60; Purity, 70.47; Glucose, 0.65; Non-sugar, 4.63, on the one hundred and fourth day of growth. The canes were dry and corky and yielded but little juice. The firm, compact seed-head is bent over as in the "Gooseneck" form, and in this lies one objection to the variety. No further trial will probably be given it on Calumet.

PLOT No. 24. LINK'S HYBRID VARIATION. Planted in the open field with seed received from Sterling, Kan. (No analyses made.)

PLOT No. 25. LINK'S HYBRID AND AMBER (Cross). Planted in the field, near the foregoing, with seed received from Sterling. Very slender canes, much damaged by wind and sprouting. (No analyses made.)

Laboratory work of the second season, 1890, began on July 19th, the one hundred and seventeenth day after the planting of the 24th of March preceding, several plots of that series appearing then sufficiently mature to need attention, and during the ensuing week ten plots were examined. Average samples of each were taken, and analyses of these made in order to determine their state of maturity, to contrast their value and to decide which plots were ready for the work of seed-selection.

All the varieties of Orange of the first planting and Link's Hybrid (Plot No. 3) were found very near full maturity, and upon these the single-stalk work was begun at once. Rainy weather had now set in, attended with high temperatures, and this continued sixty-nine days, or until September 25th, with disastrous effect upon all the plantings, causing an abnormal development of offshoots, and producing much germination of the seed in the glumes; the latter result being chiefly marked in varieties with compact heads. It had been anticipated that certain varieties known to mature early—such, for example, as Early Orange—would pass maturity before much attention would be needed by those of slower growth, as Red Liberian or Colman Cane. Yet all the varieties of the first planting were at their best by July 30th (the one hundred and twenty-eighth day), and the best analyses of this series were all obtained prior to August 25th, the one hundred and fifty-fourth day, after which period a general decline was observed.

On the 12th of August, the one hundred and ninth day from planting, the first analysis of the second series, made on an average sample drawn from Plot No. 20, Early Orange, showed a sucrose content of 14.55 per cent., and single-stalk selection was commenced with this plot on August 18th, Plots Nos. 21 and 22 coming in by the 22d of that month. Selection was continued upon canes from the above three plots until the first week of September.

Upon the third series seed selection began September 1st, the one hundred and seventh day. Alapore Jowar, a plot planted in

the same locality, was found to have suffered the almost complete loss of its seed through the inroads of swarms of insects. The canes were small and woody, perhaps owing to poorly prepared soil, shade and want of cultivation.

Plot "A," Colman Cane, was the only one with which the original plan of separately analyzing each individual cane could be accomplished. The rest, especially "D" (Late Orange), were analyzed cane by cane as long as practicable, then by cutting down the remaining canes and analyzing them as large average samples. When these average analyses were made, the whole number of seed-heads in each sample was tied in a bundle, labeled with the corresponding analysis and preserved as "general stock," which, being derived from "single-head" plots, might be appropriately used in the planting of large field-plots for experiments in tonnage and the like.

In case of each of the plots of the third planting, every normal cane was ground and its juice analyzed; hence the means of the total plot analyses were made practically comparable with each other and with the analyses of the parent canes.

To make sure that the conclusions based upon analyses of average samples were not deceptive, a trial was made on two occasions by sending out the sample-boy, ignorant of our design, with orders to cut, in the usual manner, fifteen consecutive canes from certain plots, and when these had been brought in and milled, sending him again, this time to cut down all the remaining canes, which were then ground as large samples and analyzed for comparison with the ones first taken. The results were as follows:

	SOLIDS.	SUCROSE.	PURITY.	GLUCOSE.
Early Orange, August 30, 1890.				
Fifteen canes	17.45	10.50	60.17	2.70
Whole remaining plot	16.55	12.05	72.81	1.06
White India, September 4, 1890.				
Fifteen canes	19.72	13.10	66.33	1.87
Whole remaining plot	17.45	12.65	72.49	0.65
Undendebute (same date).				
Fifteen canes	18.45	12.50	67.75	1.35
Whole remaining plot	16.45	11.90	72.34	0.51

We are hence justified in considering that the average samples taken have somewhat fairly represented the character of the plots which they were intended to represent, the variations being in

both directions and counteracting one another. It is certain that our average samples have not been too high.

The above plots, when these experiments were made, had passed maximum and were no longer useful for seed selection; but it can not be admitted that this fact injures the value of the test, which was simply the decision whether a small number of the canes could, with sufficient accuracy, be held to represent the whole.

During the 1890 experiments, an error was committed in planting many of the seed-selection plots with seed from more than one head. This was done under the fear lest a single head might not furnish enough seed to give a sufficient quantity of canes, and because, in some cases, it was desirable that there should be two plots made from the same lot. A misapprehension of the percentage of fertile seed led to this mistake, and the thinning required by the plots was evidence that single heads would have furnished all the seed ordinarily needed. Future plots for the purpose of growing pedigreed seed will, therefore, be planted from single heads only.

A record of all the varieties of sorghum which have been tried on Calumet is given in Table I., commencing in each case with the best average sample analyses obtained at the station from which they were brought, in the season preceding the first trial at Calumet.

The analyses are of average samples taken from the *parent plots*, when they are known, and when not, from the *variety only*, such substitution being indicated when it has been made.

TABLE I.

Record of Varieties tried on Calumet. Average Analyses.

1888.

VARIETY.	Analyzed at	Sucrose.	Purity.	Glucose.	Non-sugar.	REMARKS.
Early Orange (Kan. seed)	Sterling, Kan.	12.82	72.92	1.33	3.43	Parent plot
Early Orange (La. seed	Sterling, Kan.	12.90	72.07	1.13	3.87	Parent plot
Link's Hybrid	Sterling, Kan.	14.09	. . .	. . .	. . .	Parent plot
White India	Sterling, Kan.	15.07	75.96	1.02	3.58	Parent plot (?)
Red Liberian	Sterling, Kan.	14.76	. . .	. . .	. . .	Parent plot unknown.
Late Orange	Sterling, Kan.	12.73	70.76	2.32	2.94	Parent plot
Honduras	Sterling, Kan.	9.54	61.39	3.24	2.76	Parent plot
Improved Orange	Sterling, Kan.	15.00	. . .	. . .	. . .	Parent plot unknown.
Gooseneck	Sterling, Kan.	11.78	65.44	2.60	3.62	Parent plot
Sterling plot, No. 51 (1888)	Sterling, Kan.	12.80	72.03	2.27	2.70	Parent plot
Sterling plot, No. 36 (1888)	Sterling, Kan.	10.29	67.17	0.63	4.40	Parent plot
Sterling plot, No. 15 (1888)	Sterling, Kan.	12.87	69.65	0.65	5.12	Parent plot
Sterling plot, No. 14 (1888)	Sterling, Kan.	13.84	74.41	0.55	4.21	Parent plot
*White India	Sterling, Kan.	13.26	69.61	1.61	4.18	Parent plot

*No seed were saved from this plot, and its history is not continued, though a few stalks were grown on Calumet in 1889, in Plot No. 14.

1889.

VARIETY.	Analyzed at	Sucrose.	Purity.	Glucose.	Non-sugar.	REMARKS
Early Orange (Kan. seed)	Calumet Plant'n, La.	16.02	75.21	1.95	3.33	
Early Orange (La. seed)	Calumet Plant'n, La.	16.30	76.16	2.50	2.60	
Link's Hybrid	Calumet Plant'n, La.	16.44	79.42	1.16	3.10	
White India	Calumet Plant'n, La.	10.51	64.48	. . .	. . .	No average analyses made; mean of all single stalks given instead.
*Red Liberian	Calumet Plant'n, La.	9.87	57.38	. . .	. . .	
Late Orange	Calumet Plant'n, La.	16.44	79.42	. . .	. . .	
Honduras	Calumet Plant'n, La.	7.45	55.18	3.95	2.10	
Improved Orange	Calumet Plant'n, La.	14.81	77.14	2.16	2.23	
Gooseneck	Calumet Plant'n, La.	11.74	69.06	3.11	2.15	
Sterling plot, No. 51 (1888)	Calumet Plant'n, La.	8.17	57.53	. . .	. . .	
Sterling plot, No. 36 (1888)	Calumet Plant'n, La.	7.85	59.02	2.96	2.49	
Sterling plot, No. 15 (1888)	Calumet Plant'n, La.	. . .	. . .	. . .	. . .	No average analyses made in 1889
Sterling plot, No. 14 (1888)	Calumet Plant'n, La.	10.11	58.37	3.12	3.97	
Honduras Variation	Sterling, Kan.	. . .	. . .	. . .	. . .	Sterling analyses of 1889 not known.
Undendebule	Sterling, Kan.	. . .	. . .	. . .	. . .	Sterling analyses of 1889 not known.
Colman Cane	Sterling, Kan.	. . .	. . .	. . .	. . .	Sterling analyses of 1889 not known.
Planter's Friend	Sterling, Kan.	16.21	79.22	0.55	3.70	
Ubehlana	Sterling, Kan.	14.07	72.75	1.97	3.30	
Link's Hybrid and White India (Cross)	Sterling, Kan.	. . .	. . .	. . .	. . .	

*No satisfactory seed were secured in 1889, and Calumet Plot No. 5A, 1890, was grown from seed brought from Sterling, Kan., to replace Calumet Plot No. 5, of 1889.

1890.

VARIETY.	Analyzed at	Sucrose.	Purity.	Glucose.	Non-sugar.	REMARKS.
Early Orange (Kan. seed)	Calumet Plant'n, La.	15.55	77.82	1.11	3.32	
Early Orange (La. seed)	Calumet Plant'n, La.	14.65	76.82	1.80	2.62	
Link's Hybrid	Calumet Plant'n, La.	15.80	77.45	0.56	3.61	
White India	Calumet Plant'n, La.	15.25	77.33	0.87	3.60	
*Red Liberian	Calumet Plant'n, La.	12.80	68.38	3.24	2.60	Calumet Plot, No. 5A.
Late Orange	Calumet Plant'n, La.	16.30	78.82	1.41	2.97	
Honduras (discontinued)	Calumet Plant'n, La.	. . .	. . .	. . .	. . .	
Improved Orange	Calumet Plant'n, La.	14.81	77.14	2.16	2.23	
Gooseneck	Calumet Plant'n, La.	. . .	. . .	. . .	. . .	No analytical work was done on this plot in 1890.
Sterling plot, No. 51 (1888)	Calumet Plant'n, La.	14.50	74.66	1.23	3.69	
Sterling plot, No. 36 (1888)	Calumet Plant'n, La.	14.60	66.45	1.99	4.68	
Sterling plot, No. 15 (discon'd)	Calumet Plant'n, La.	. . .	. . .	. . .	. . .	
Sterling plot, No. 14 (1888)	Calumet Plant'n, La.	13.05	70.15	1.54	3.45	
Honduras Variation	Calumet Plant'n, La.	15.55	77.52	1.22	3.34	
Undendebule	Calumet Plant'n, La.	16.25	77.71	0.72	3.04	
Colman Cane	Calumet Plant'n, La.	16.45	78.57	0.69	3.77	
Planter's Friend	Calumet Plant'n, La.	15.55	77.10	1.08	3.42	
Ubehlana	Calumet Plant'n, La.	14.10	74.08	2.11	2.91	
Link's Hybrid and White India (Cross)	Calumet Plant'n, La.	14.00	73.61	1.35	3.67	
Alapore Jowar	Calumet Plant'n, La.	10.50	74.20	0.66	2.99	First year's cultivation in America, here and in Kansas.

*Seed grown in Sterling, Kan., Plot No. 131, of 1889, of which the best average analysis is not known.

Table II., following, presents the result of all the single stalk analyses of sorghum made here, in a form to facilitate comparison of the work done in 1889 and 1890, and to show the improvement (or its reverse) resulting from one year's propagation by selected stock. In actual field experiments, single varieties have been represented in different plots, of various origin or dates of planting: but to avoid needless complication each variety has been treated, in collating the analyses, as though of but one plot, and time of seeding, no distinction, for example, being made between Plots 1 and 2 of Early Orange, or the 1890 Plots 3, 21 and "C" of Link's Hybrid, the former two having different origin and the latter three being plantings of different date. The standard of purity and sucrose adopted, it should be said, is quite arbitrary, and is chosen as a fair average for our sorghum.

TABLE II.

In the table is given the number of single stalk analyses showing Purity above 77 per cent., and Sucrose above 16 per cent. per hundred canes of each variety of sorghum grown during 1889 and 1890 on Calumet.

1889.

VARIETY.	Total No. Canes Examined.	Per Cent. Over 77 Purity.	Per Cent. Over 16 Sucrose.
Early Orange	420	3.09	7.62
Link's Hybrid	430	10.93	13.72
White India	107	.93	3.74
Red Liberian	111	none	none
Late Orange	254	5.12	6.69
Honduras	23	none	none
Improved Orange	141	2.13	3.55
Gooseneck	64	3.13	none
Sterling No. 51 (of 1888)	128	none	none
Sterling No. 36 (of 1888)	66	1.51	none
Sterling No. 15 (of 1888)	60	1.67	16.67
Sterling No. 14 (of 1888)	106	none	none

1890.

VARIETY.	Total No. Canes Examined.	Per Cent. Over 77 Purity.	Per Cent. Over 16 Sucrose.
Early Orange	277	4.33	.72
Link's Hybrid	269	7.81	10.41
White India	No single stalk analyses made		
Red Liberian	47	none	none
Late Orange	107	3.74	5.61
Honduras Variation	50	2.00	none
Improved Orange	36	5.56	25.00
Gooseneck	12	none	none
Sterling No. 51 (of 1888)	29	none	none
Sterling No. 36 (of 1888)	49	none	none
Sterling No. 14 (of 1888)	44	none	none
Undendebule	176	18.75	36.36
Colman Cane	201	24.38	37.31
Planter's Friend	77	10.39	25.94
Ubehlana	74	none	none
Link's Hybrid and White India (Cross)	78	none	none
Alapore Jowar	14	none	none

In the foregoing table, the only marked improvement in both sucrose and purity is exhibited by Improved Orange. Early Orange gained slightly in purity, while falling off greatly in sucrose content. Link's Hybrid shows decline in both sucrose and purity, which is true also of Late Orange. Several varieties failed altogether to attain the standard of purity or sucrose in either year, and in case of these, as also of varieties cultivated here for but one of the seasons given, no improvement or depreciation is shown in the table.

Unfortunately, in the two seasons thus contrasted, an important condition for rendering the comparison a fair one was lacking, due to the disturbing influence of the opposite character of the growing seasons experienced by the plantings of the two years, the first season (1889) giving a wet period during germination, and a drouth later on, and the second (1890) reversing the order completely for the first series of experiments, and giving the two later ones a wet season throughout. It is impossible to say just in what way, or how much these varying seasons have influenced the cultural work, but that their effect has been the prime factor in the many irregularities encountered seems almost certain.

In Table III. are given the best three analyses of single stalks for each plot grown at Calumet during 1890. A few varieties are omitted, which for various reasons were not subjected to sufficient analyses to warrant their insertion. The highest percentages of sucrose and of purity are taken, regardless of the full analysis of the canes, and in many instances the highest percentage in sucrose may be furnished by the stalk giving purity third in rank, etc. The highest analysis for each planting and plot of a variety is given.

TABLE III.

Highest Three Single Canes of Each Plot in Sucrose and in Purity for the year 1890.

	Sucrose.	Purity.		Sucrose.	Purity.		Sucrose.	Purity.
Early Orange Plot No. 1 (50 Canes)	15.90 15.70 15.50	78.29 77.99 77.85	Sterling No. 51 Plot No. 10 (29 Canes)	15.50 15.30 15.20	76.06 75.81 75.21	Early Orange Plot No. 20 (109 Canes)	16.15 15.85 15.65	77.62 77.02 76.16
Early Orange Plot No. 2 (50 Canes)	16.05 15.95 15.90	78.87 78.74 77.88	Sterling No. 36 Plot No. 11 (49 Canes)	13.90 13.90 13.70	74.50 71.25 73.80	Link's Hybrid Plot No. 21 (85 Canes)	16.00 16.00 15.85	80.60 79.46 78.28
Link's Hybrid Plot No. 3 (119 Canes)	16.80 16.75 16.70	78.67 77.41 77.33	Undendebule Plot No. 12 (85 Canes)	18.10 18.05 17.50	78.75 78.63 77.74	Undendebule Plot No. 22 (91 Canes)	18.00 18.00 17.85	81.63 80.93 78.84
Red Liberian Plot No. 5A (47 Canes)	15.00 14.25 14.20	75.68 71.53 70.37	Sterling No. 14 Plot No. 13 (44 Canes)	15.50 15.35 15.25	76.34 76.02 75.95	Alapore Jowar Plot No. 23 (14 Canes)	13.00 12.60 12.50	71.11 72.38 71.04
Late Orange Plot No. 6 (72 Canes)	16.75 16.60 16.50	79.58 79.35 76.14	Colman Cane Plot No. 16 (105 Canes)	17.55 17.40 17.15	78.93 78.93 78.64	Colman Cane Plot "A" (96 Canes)	17.85 17.65 17.55	82.43 78.88 78.71
Honduras Variation Plot No. 7 (50 Canes)	15.75 15.55 15.50	77.05 76.91 76.84	Planter's Friend Plot No. 17 (77 Canes)	17.65 17.65 17.55	78.63 77.92 77.80	Early Orange Plot "B" (68 Canes)	15.35 14.75 14.75	76.59 76.13 76.11
Improved Orange Plot No. 8 (36 Canes)	18.25 17.35 17.30	77.51 77.46 76.59	Ubehlana Plot No. 18 (74 Canes)	14.60 14.60 14.45	73.43 73.24 73.18	Link's Hybrid Plot "C" (65 Canes)	15.60 15.25 15.20	79.97 78.54 78.50
Gooseneck Plot No. 9 (12 Canes)	15.20 15.05 14.90	75.17 73.81 73.70	Link's Hyb'd and W.In. cross Plot No. 19 (78 Canes)	15.50 15.35 15.30	76.42 76.33 76.29	Late Orange Plot "D" (35 Canes)	10.20 9.75 9.50	69.96 68.35 66.76

Early Orange (Plot No. 2) of the first planting is seen to be better in purity than the same variety grown later in Plot No. 20, which in turn is better than Plot "B," of the third planting. Link's Hybrid appears to lose sucrose but to retain purity, as the date of planting is later, but the differences of soil may have much influence in both cases. The two plantings of Undendebule show but slight difference, which is true also of Colman Cane, Plots Nos. 16 and "A."

Careful examination of all average analyses, field notes and seed-heads of both seasons has led to the selection of several varieties which show special excellence in points considered essential in sorghum, which is to be grown for its sugar. Table IV. shows the varieties which in either year have been noted for possessing any one or more of such characters.

TABLE IV.

The varieties which have given, with us, the best results in the several regards mentioned during the experiments carried on in the seasons of 1889 and '90, are here given. Those six varieties have been chosen in each case which have given the highest analyses as average samples.

BEST SIX IN 1889.

	High Sucrose.	High Purity.	Low Non-sugar.	Best Seed.	Large Canes.
Best . .	Late Orange.	Late Orange.	Late Orange.	Early Orange.	Sterling No. 36
Second .	Link's Hybrid.	Link's Hybrid.	Sterling No. 51	Link's Hybrid.	Honduras.
Third .	Early Orange.	Sterling No. 15	Early Orange.	Red Liberian.	White India.
Fourth .	Imp'd Orange.	Imp'd Orange.	Imp'd Orange.	. . . . .	Link's Hybrid.
Fifth . .	Sterling No. 15	Early Orange.	Honduras.	. . . . .	Gooseneck.
Sixth . .	Gooseneck.	Gooseneck.	Gooseneck.	. . . . .	. . . . .

BEST SIX IN 1890.

	High Sucrose.	High Purity.	Low Non-sugar.	Best Seed.	Large Canes.
Best . .	Colman Cane.	Link's Hybrid.	Undendebule	Colman Cane.	Ubehlana.
Second .	Imp'd Orange.	Colman Cane.	Early Orange.	Ubehlana.	Colman Cane.
Third .	Undendebule.	Late Orange.	Ubehlana.	Link's Hybrid.	Plantr's Fr'nd
Fourth .	Early Orange.	Imp'd Orange.	Link's Hybrid.	Undendebule.	Link's Hybrid.
Fifth . .	Late Orange.	Undendebule.	Late Orange.	Plantr's Fr'nd	Early Orange.
Sixth . .	Plantr's Fr'nd	Plantr's Fr'nd	Red Liberian.	Early Orange.	Red Liberian.

The varieties mentioned in Table V. as producing the "best seed" have been chosen not only regarding the quantity of seed produced, but also its freedom from sprouting in damp weather and immunity from rust or blight, and its fertility so far as this may be judged from the result of two years' propagating. Freedom from sprouting seems to depend largely upon the character of the panicle and its tendency to retain water. Size of stalk is, of course, based upon comparison among our own plots.

TABLE V.

Varieties noted for valuable qualities during both seasons' culture on Calumet Plantation.

High Sucrose.	High Purity.	Low Non-sugar.	Best Seed.	Large Canes.
Late Orange.	Link's Hybrid.	Late Orange.	Link's Hybrid.	Link's Hybrid.
Early Orange.	Late Orange.	Early Orange.	Early Orange.	
Improved Orange.	Improved Orange.			

Table IV. includes several varieties in the 1890 list, which, not being grown here the season preceding, can not appear in Table V., although in the single year's trial they have given higher analyses than, and in other respects have rivaled, many older varieties. As seen in Table IV., Link's Hybrid and Early Orange each occurs *eight times* in the list for the two years, Late Orange *six* and Improved Orange *five* times. Gooseneck is mentioned *four* times in the 1889 list, as are Colman Cane, Undendebule and Planter's Friend in that of 1890. Red Liberian and Ubehlana appear *three* times each; the former in both years, the latter in 1890 only.

Having considered the merits of varieties tried at Calumet during 1889 and 1890, these which follow are chosen as worthy of continued experiment; and as this work is to be pursued another year, selection from among them is recommended, if all are not again planted: Link's Hybrid, Late Orange, Improved Orange, Early Orange, Colman Cane, Undendebule, Planter's Friend, Ubehlana and Sterling Plot No. 14, of 1888.

White India gave much promise the first year of its trial here, although but few canes were raised because of faulty seed, which failed to germinate well. These few, however, were of good size

and produced juice of good quality. But in 1890 the seed from large and apparently strong canes of the former season yielded canes much smaller and slenderer than those of the parent plot, and scarcely any seed was obtained from them, the glumes being either empty or inclosing blighted grains, crumbling on pressure. This, perhaps, was partly the effect of wet weather, but it seems also probable that the sparse stand of 1889 may have hindered perfect fertilization of the flowers. Although in many orders of plants cross-pollenization is necessary to fertility, the writer can not say whether this is in any degree true also with sorghum. Should White India be retained here, entirely new stock should be procured.

Red Liberian might with advantage be continued, though it has not given very good results in the field or laboratory thus far at Calumet. After heading the list of varieties for excellence at Sterling in 1888, it fairly fell out of the race at that station again in 1889. Its growth here as a forage crop for many years, and with entire success, shows the fitness of the variety, from the purely agricultural standpoint to the local conditions of climate, soil, etc., and by selection it might be improved.

DISEASE, DAMAGE BY INSECTS, ETC.

While carrying on the cultural experiments with sorghum, quite full notes were kept of the diseases, abnormal habits of growth and insect depredations affecting the plant from time to time. Early in course of the work of 1889, Mr. Thompson noticed that many canes broke off very mysteriously a short distance above ground, and on examination he found this to be the work of a burrowing larva. After laboratory work commenced, many canes were found attacked in this manner by the "tropical borer" (*Chilo saccharalis*), which enters near a node or joint of the stalk and tunnels through the stem until the next joint stops his progress, canes thus injured usually developing an intense red coloration of the pith and juice of the punctured section, this often extending several joints above and below the one eaten into. The deserted burrows were sometimes occupied by colonies of a small beetle not identified. The cane borer was unusually common, that season, in the tropical cane crop.

A diseased condition of many canes was also very noticeable; when split longitudinally the pith was more or less extensively

and deeply red, and the juice expressed from such stalks was colored in the same manner. The leaves, sheaths and portions of the stem exhibited patches of dark reddish orange, these often nearly black centrally. This diseased condition is treated at some length in Bulletin No. 5, of the Kansas State Agricultural College, for 1888, and is attributed to a microscopic organism, *Bacillus sorghi*, said to exist in the affected plants and in the soils where they have been grown.

According to the notes on this subject, the varieties which in 1889 were found worst injured by borers (varying from 20 to 90 per cent. of the whole number of canes examined) were: Early Orange (Plot No. 1), both plots of White India, Improved Orange, Calumet Plot No. 11 (Sterl. Plot No. 36, 1888) and Calumet Plots 13 and 13P (Sterl. Plot No. 14, 1888). Less damage was sustained by Red Liberian, Late Orange, Honduras and Calumet Plot No. 10 (Sterl. Plot No. 51, 1888). Plot No. 2 of Early Orange was almost free from borers, and Link's Hybrid notably so.

Worst affected by the *Bacillus sorghi* were Plot No. 1, of Early Orange, Red Liberian, Honduras and Calumet Plot No. 10. Late Orange, Improved Orange, Gooseneck and Calumet Plot No. 11 were not so much diseased, and Plot No. 1 of Early Orange, Link's Hybrid, both plots of White India and the duplicate Calumet Plots Nos. 13 and 13P scarcely at all.

Ants are sometimes troublesome eating the seed while it is in a soft condition, but they are not numerous, and their inroads are usually confined to a few canes in one or two rows.

The freedom from the cane borer noticed in the sorghum as well as in the tropical cane of 1890, is considered to have resulted from the very warm winter of 1889 and 1890, inducing premature emergence of the grubs, and their probable destruction in great numbers by the late and severe freeze of March, 1890. The disease caused by the *B. sorghi* was comparatively rare also among the 1890 plots, and occurred often enough to be noticed only in the following: Early Orange, Ubehlana, Link's Hybrid, Undendebule and Late Orange, affecting canes of these varieties equally in the first, second and third plantings.

The tendency of sorghum cane to sprout supplemental seed-heads from the axils of the leaves is a common fault, and though these offshoots are usually few and confined to the upper part of the stalk, yet in long-continued rains, or after injury to the stem,

the whole energy of the plant seems devoted to their production, two and even more growing from every joint. Additional stalks or tillers often start from the base of the cane, some of these connected with the original rootstock, depriving the parent stem of part of its proper nourishment; others, with their own rootlets, exhausting the soil to no useful purpose, and in this manner being analogous to any "weeds." Adventitious roots form, sometimes, at one or more of the lower nodes. All these growths, when present in a considerable degree, detract from the value of the crop as a source of sugar by lowering the quality of the juice and interfering with the easy removal of tops and "trash."

Cultivating before the plants have spread their roots far laterally, and care to guard against disturbing them will reduce the tillering measurably; and though we can not regulate the influence of weather, we can choose varieties and select canes for seed which show least propensity to offshoots. The summer of 1890 furnished in this matter an excellent, though unsought, test of the varieties grown here, for those which could undergo the incessant rains and murky weather of that season and still remain reasonably free from this defect are to be commended. Colman Cane and Ubehlana are two varieties which deserve special mention in this connection.

In the experimental culture of sorghum, preservation of desirable strains is often made difficult or impossible from causes which injure the seed or affect its vitality. Insects, blight, and the influence of unfavorable weather are the chief factors in this; and since the number of canes grown for selection purposes is necessarily limited, and the varieties must be planted in isolated rows, the damage is generally considerable when it occurs, and not many canes escape. Separation of such plots from surrounding crops increases liability to injury from insects especially, all varieties suffering equally in this. Blight, rust, or mildew is frequent in wet or cloudy seasons, but seems to attack the seed of some varieties more than that of others equally exposed, the worst sufferers among the Calumet plots having been those of White India, of which not one reliable seed-head was produced in 1890, though very little seed of other sorts was lost through this cause in either year.

Another and widely felt result of wet weather, during the harvest of 1890, was a general sprouting which took place among

the seed while yet on the heads, all which had so germinated, of course being utterly valueless for planting. Least sprouting of the seed took place with Colman Cane, Ubehlana, Link's Hybrid, Undendebule and Planter's Friend, and from Early Orange, of three plantings, most of the seed was saved in apparently good condition. Sorghum shares all these liabilities to damage in common with most other cereals, and allusion is made to them chiefly to point out some of the obstacles which must be met in the attempt to develop the plant by seed selection.

Quite aside from the mischief done by insects to the seed while still in the field, another and more insidious—because often unnoticed—danger springs from the hatching of eggs ("nits") of weevils and other pests, which are put away with the selected seed. These are often so numerous that a packet left undisturbed for a few weeks may be found, when opened, alive with them. Several species of small beetles, and a few of the smaller Lepidoptera breed numerously in the seed-heads of the sorghum grown here; and being aware of this, all the seed intended to be preserved has been packed in closely stoppered glass bottles or tight metal cans, in some cases after mixing plentifully with Persian insect powder. About two weeks after the seed-selection work had ended, on examination of one of the larger packages of seed, which contained a large quantity of the insect powder, it was found infested with small beetles and their grubs, in lively health, and several small moths fluttered weakly about or clung to the sides of the can. Further search revealed the fact that almost every lot of seed was in a similar condition. An application of ether was made experimentally, and a small quantity dropped into each packet, when all were tightly closed again, packed away, and not again looked into during the busy months of the "grinding" which then followed. Five months later another examination of the stock of seed was made, and in the large can referred to (containing a general selection of seed from Colman Cane) was found another and even larger throng of beetles, if anything more active than before, and the same was found to be the discouraging state of things in nearly the whole stock, excepting among the smaller packets of seed from single heads, which had been more readily cleaned when first packed.

These facts suggest the thought that, should sorghum become a recognized sugar crop in Louisiana, the business of raising high

class seed would probably be better left to others than the sugar-growers, for special experience, watchfulness and care that few could find time to give are required by the work. Better success, also, might be met by importing seed for this crop from sections where less difficulty is encountered from the myriads of destructive insects which swarm here and make the sorghum-field their home, infesting the seed-heads, depositing their eggs among them and making it imperative to take every precaution and keep continual watch, which may even then be unavailing to preserve the gathered seed. Suitable varieties of sorghum being once established, these could be preserved and propagated at some fit Louisiana station, and sufficient seed sent elsewhere each year—say, to Kansas—where might be grown the larger supply required for the next year's crop here, thus keeping the variety acclimatized to Louisiana, while raising the field seed elsewhere, with less risk of its failing to germinate when planted.

TIME FOR PLANTING.

Once successful in finding or originating a profitable variety of sorghum cane for the sugar plantations of Louisiana, it then becomes essential to learn what is the best time to plant it in order that the crop may be mature in time to be harvested and gotten entirely out of the way before the later tropical cane needs attention. Varieties which have thus far done best here have required about one hundred and twenty days' growth from the time of seeding to that of maturity; and as an auxiliary crop would best be "milled" during the six or seven weeks prior to October 15th, it seems that a first planting made about May 1st, succeeded by a smaller one two weeks later, would, with ordinarily good weather, insure ripe cane throughout such a season.

Separate plantings made at Calumet with several varieties failed to throw the hoped for light upon this question, owing to the abnormal growth induced by an untoward season; a like trial another year may succeed better, and will probably be made.

STABILITY AND VARIABILITY OF SORGHUM.

In a sugar-producing plant it is an important requirement that when its maximum content of sugar has been reached, this shall be sustained for a reasonable period, and not too rapidly decline:

for it is not usually profitable to harvest a crop until its highest value can be realized. Sorghum, it has quite often been said, begins to fall off very soon in sugar and purity after its maximum has been attained, but many varieties tried on this plantation have, on the contrary, continued to show a high juice analysis for periods ranging from twenty to thirty days. In 1889, for example, when the dry weather of the later autumn favored a slow and regular development, Link's Hybrid furnished, during one month, canes yielding uniformly above fourteen per cent. sucrose with a purity averaging seventy-five per cent. and over; and during 1890, though suckering badly from the damp, hot season, equally good cane of the same variety was found by analysis throughout the period extending from July 21st to August 18th, and other varieties did as well as this.

The wide difference in sugar content and other qualities noted among single canes grown from seed of the same parent stalk under (apparently) identical conditions, has been often remarked by those who have made sorghum a subject of experiment. When investigating the merits and failings of any plant proposed as an adjunct to or substitute for tropical cane, it is natural that the latter should be made the standard of comparison. With this in view, a number of analyses have been made in the course of the Calumet experiments, having for their object a determination and comparison of the variation in juice-constituents of sorghum and ordinary Louisiana cane, one stalk with another.

In 1889 this subject could not be given as much attention as it deserved. Ten adjacent stalks of Link's Hybrid sorghum were cut and analyzed separately, and ten stalks of "Purple" and "Ribbon" cane (mixed) were taken from the field and treated in like manner on the same date. The result of this experiment is shown in full in Table VI., and from the figures there given it would seem that the variation among the stalks of tropical cane is the greater. A single experiment of this sort, however, on so few canes, is far from conclusive.

A more extensive experiment of the same character was made in 1890, and a comparison was made of two varieties of sorghum, with each other and with tropical cane: the degree of variation is expressed in form of percentage, from which the general deduction may be made that variability (stalk with stalk) is a trait shared in nearly equal degree by sorghum and its more prosperous relative.

The latter experiment is given in Table VII. Table VI., also, strikingly illustrates the difference of the two plants in content of non-sugar, the great excess of this group of bodies in the sorghum cane juice appearing on comparison of the two "non-sugar" columns, and serving to accentuate what is later said concerning their influence and composition.

TABLE VI.

Comparison Sorghum and Tropical Cane as to Variability Among Unselected Single Stalks of Each.

Both Grown Upon Calumet Plantation, Louisiana, Season of 1889.

SORGHUM—LINK'S HYBRID. Ten (10) Adjacent Canes taken from the same row, November 4, 1889.					SUGAR CANE—"PURPLE" AND "RIBBON." Ten (10) Adjacent Canes taken from a single row, November 4, 1889.				
No.	Corrected Solids.	Sucrose.	Glucose	Non-sugar.	Exponent.	No.	Corrected Solids.	Sucrose.	Glucose	Non-sugar.	Exponent.
1	22.20	17.04	0.71	4.45	76.75	1	15.67	11.91	1.82	1.94	76.00
2	21.39	16.18	0.54	4.67	75.64	2	16.77	13.91	1.25	1.61	82.95
3	19.88	13.98	0.63	5.27	70.32	3	15.17	11.10	2.16	1.91	73.16
4	21.85	15.77	0.65	5.43	72.18	4	13.10	8.72	2.26	2.12	66.64
5	21.85	16.25	0.53	5.07	74.37	5	15.87	12.64	1.46	1.77	79.65
6	22.25	16.70	0.73	4.82	75.05	6	15.89	12.64	1.67	1.58	79.67
7	21.68	15.59	0.62	5.47	71.91	7	13.83	9.74	2.28	1.81	70.64
8	21.41	15.81	0.68	4.92	76.10	8	14.62	10.98	1.71	1.93	75.10
9	21.68	16.50	0.68	4.50	73.84	9	15.53	12.32	1.49	1.72	79.33
10	21.18	15 53	. . .	. . .	73.32	10	15.06	11.41	1.90	1.75	75.76
Averages . .		15.94	0.64	4.96	74.00	Averages . .		11.54	1.80	1.81	76.17

DIFFERENCE BETWEEN EXTREMES.

	Sorghum.	Tropical Cane.
Solids	2.37	3.67
Sucrose	3.06	3.92
Glucose	0.20	1.03
Non-sugar	1.02	0.54
Exponent	6.43	16.31

TABLE VII.

SORGHUM, 1890.—*Summary of Variability Experiments.*

(A) SORGHUM. 58 SINGLE STALKS OF "LINK'S HYBRID" (PLOT C).	Cor. Brix.	Per Cent. Sucrose.	Per Cent. Purity.
Mean of analyses	17.14	12.63	73.69
Maximum	18.88	14.75	78.50
Minimum	14.30	9.80	60.11
Difference of extremes .	4.58	4.95	18.39
Per cent. canes varying 2 per cent. or less from mean	. . .	93.10	65.51
Per cent. canes varying 2 to 5 per cent.	. . .	6.90	29.31
Per cent. canes varying over 5 per cent.	. . .	. . .	5.18

(B) SORGHUM. 58 SINGLE STALKS OF "COLMAN CANE" (PLOT A).	Cor. Brix.	Per Cent. Sucrose.	Per Cent. Purity.
Mean of analyses	20.27	15.35	75.73
Maximum	23.08	17.85	82.43
Minimum	10.88	6.35	58.36
Difference of extremes .	12.20	11.50	24.07
Per cent. canes varying 2 per cent. or less from mean	. . .	77.59	81.03
Per cent. canes varying 2 to 5 per cent.	. . .	20.69	15.52
Per cent. canes varying over 5 per cent.	. . .	1.72	3.45

(C) TROPICAL CANE. 58 STALKS OF "PURPLE CANE" (STUBBLE).	Cor. Brix.	Per Cent. Sucrose.	Per Cent. Purity.
Mean of analyses . . .	14.51	11.42	78.70
Maximum	16.40	13.90	84.80
Minimum	12.90	9.10	69.60
Difference of extremes .	3.50	4.80	15.20
Per cent. canes varying 2 per cent. or less from mean	. . .	96.55	46.55
Per cent. canes varying 2 to 5 per cent. . . .	. . .	3.45	41.38
Per cent. canes varying over 5 per cent. . . .	. . . . .		12.07

COMPARISON OF LARGE AND SMALL CANES, AND OF CANES WITH LARGE AND SMALL SEED-HEADS.

On August 1, 1890, thirty canes of Link's Hybrid were cut, selecting the largest stalks, and the next day thirty of the smallest from the same plot. The canes were ground singly, and their juices tested by the Brix spindle, the twelve samples giving the highest per cent. solids being analyzed in case of each set. Four of the large and two of the small canes gave juices containing sucrose at or above sixteen per cent.

LARGE AND SMALL CANES, AVERAGE.

	LARGE CANES.	SMALL CANES.
Solids	20.72	20.91
Sucrose	15.79	15.29
Purity	76.21	73.12

As the above figures show, the choice is in favor of the larger canes. The general work of the season, however, indicates that no prediction can be safely made which is based on the size of stalk, always provided that their stage of growth is the same, and that canes so compared are of varieties not too widely differing in the period required to attain maturity.

At the same time with the preceding experiment, samples were drawn from a plot of Colman Cane selecting twenty each of canes with respectively the largest and smallest seed-heads to be found. Of the canes with largest heads, ten gave juices passing the arbitrary Brix test, and in like manner nine samples of juice were selected from the canes with the smallest heads. Eight of these juices, in each set, were found to contain sucrose sixteen per cent. or over.

LARGE AND SMALL SEED-HEADS, AVERAGE.

	LARGE HEADS.	SMALL HEADS.
Solids	20.90	21.33
Sucrose	16.22	16.28
Purity	77.61	76.32

The difference in the analyses is not sufficient to demonstrate that the size of the seed-head is any index of the quality of the juice in the cane.

TABLE VIII.

On August 3 (1890). Plot No. 1 of Early Orange being useless for further seed selection, the tops of one-half the canes yet standing were removed, and the remainder of the plot left intact. Analyses were made at weekly intervals, taking a like number of canes from the "Topped" and "Untopped" parts of the plot to make comparison.

The figures obtained indicate that no marked difference is produced in canes which have attained maturity and ripened their seed. That topping very immature canes would have beneficial influence is, to say the least, very doubtful, as the secondary heads which would inevitably be put forth to replace the loss might hasten the deterioration of such cane.

NOT TOPPED.

Serial Number.	Date of Analysis.	Number Canes Used.	Corrected Brix.	Per Cent. Sucrose.	Purity.	Per Cent. Glucose.	Glucose Ratio.	Per Cent. Non-sugar.	Non-sugar Ratio.
42	August 6	10	19.95	14.35	71.93	2.10	14.63	3.50	24.39
64	August 12	10	19.05	14.15	74.27	1.52	10.74	3.38	23.88
87	August 19	15	18.22	13.00	71.35	1.29	9.92	3.93	30.23
116	August 25	15	17.22	12.50	72.59	.97	7.76	3.75	30.00
Average		50	18.61	13.50	72.54	1.47	10.89	3.64	26.96

TOPPED AUGUST 3.

Serial Number.	Date of Analysis.	Number Canes Used.	Corrected Brix.	Per Cent. Sucrose.	Purity.	Per Cent. Glucose.	Glucose Ratio.	Per Cent. Non-sugar.	Non-sugar Ratio.
45	August 6	10	19.45	13.90	71.41	1.73	12.45	3.82	27.41
65	August 12	10	19.05	13.85	72.65	1.61	11.62	3.59	25.92
86	August 19	15	18.82	13.65	72.51	1.31	9.59	3.86	28.28
117	August 25	15	15.62	11.00	70.42	1.63	14.82	2.99	27.18
Average		50	18.24	13.10	71.82	1.57	11.99	3.57	27.25

YIELDS PER ACRE.

In 1889 a few experiments were undertaken for the purpose of learning something of the yield per acre of sorghum cane. This was done with the varieties (Early Orange Plot No. 2, Link's Hybrid Plot No. 3 and Late Orange Plot No. 6) which were at that time most promising in the light of laboratory and field work. Table IX. (chiefly the work of Mr. W. J. Thompson) is given below, showing the result:

TABLE IX.

Field Experiments in Sorghum, 1889–90. Yields per Acre.

	PLOT 2.	PLOT 3.	PLOT 6.
NUMBER CANES	30.	31.	30.
Date	Oct. 23.	Oct. 23.	Oct. 23.
Weight of field cane, lbs.	28	32½	32½
Weight of clean cane, lbs.	18	22	21
Weight of seed-heads and 15 in. stems, lbs.	3	3	3
Weight of trash by difference, lbs.	7	7½	8½
Weight of clean seed, lbs.	2.75	2.5	2.75
Average weight of field cane, per cane, lbs.	0.933	1.048	1.083
Average weight of clean cane, per cane, lbs.	0.600	0.71	0.70
Average weight of seed-heads and 15 in. stems, per cane, lbs.	0.100	0.097	0.10
Average weight of trash, per cane, lbs.	0.233	0.241	0.283
Average weight of clean seed, per cane, lbs.			
Solids, spindle	21.40	20.70	20.70
Sucrose, single polarization	16.30	16.44	16.44
Glucose	2.50	1.16	2.39
Solids, not sugar	2.60	3.10	1.87
Ash	0.8024	0.8876	0.8470
Organic solids, not sugar	1.7976	2.2124	1.0230
Purity	76.16	79.42	79.42
Glucose ratio	15.33	7.05	14.53
Available sugar (S., 1½ G.) per cent.	12.55	14.70	8.55
Average canes per acre 1 cane to 3 in., 7 ft. rows, tons			
Average canes per acre 1 cane to 3 in., 4 ft. rows, tons	43.560	43.560	43.560
Average tonnage field cane per acre, 1 cane to 3 in., 7 ft. rows, field cane			
Average tonnage field cane per acre, 1 cane to 3 in., 4 ft. rows, field cane			
Average tonnage clean cane per acre, 1 cane to 3 in., 7 ft. rows, clean cane			
Average tonnage clean cane per acre, 1 cane to 3 in., 4 ft. rows, clean cane	13.068	15.46	15.24
Average clean seed per acre, 1 cane to 4 in., 7 ft. rows, lbs.			
Average clean seed per acre, 1 cane to 4 in., 4 ft. rows, lbs.			
Available sugar per acre, 1 cane to 4 in., 7 ft. rows, lbs.			
Available sugar per acre, 1 cane to 4 in., 4 ft. rows, lbs.	2742.175	3799.50	3275.32
Available sugar per ton, clean cane, 7 ft. rows			
Available sugar per ton, clean cane, 4 ft. rows	209.83	245.76	244.24

Available sugar per acre and per ton is calculated on the basis of twelve per cent. fiber and eighty-eight per cent. juice, and an extraction of ninety-six per cent. on the total juice, which diffusion gives in reasonably good practice.

It is understood that an experiment on so small a scale is not a fair one, but it is as close an approximation as could be reached, and is of value in comparing one variety with another.

CHEMICAL STANDARDS IN SEED SELECTION.

When a large number of canes have been analyzed, and the time arrives when selection must be made from among their seed-heads of those which it is desirable to save, the question arises as to what shall be retained and what rejected. To choose the proper seed would be quite a simple matter were but one constituent—sucrose, for example—to be considered. In reality there are four—sucrose, purity, glucose and non-sugar—each of which should have due influence upon the choice. The *ideal* sugar plant would be one containing in its juice only sugar (sucrose) and water, and the nearer a sorghum juice approximates in its analysis to this composition, the more valuable is it. We find our juice, however, to contain besides sucrose and water varying proportions of other substances, the best known of them being glucose, which, with numerous imperfectly understood organic bodies (starch, organic acids, gums, etc., collectively termed "organic non-sugars") form a large part of the solids, and injure the quality of the juice.

Hence *purity of juice* (per cent. ratio of sucrose to total solids) should be one of the chief standards. High purity and high sucrose content are usually, though not invariably, co-existent, and it seems the best plan to make the first selections upon purity as a basis. Having done this, the majority of the seed-heads have been eliminated, and there remains a comparatively small number derived from canes of high and nearly equal purity of juice and sucrose content, from which it now remains to select a few which shall be representative of the highest type of excellence. At this stage it seems to be the common practice to make the final selection from the heads representing canes of lowest per cent. glucose, but during work here the belief has been reached that this procedure is not the best. Analyses indicate that for approximately

equal purity, the juice containing *most* glucose has *least* of the highly objectionable starchy and gummy constituents, and the actual work of Calumet factory for the past three years has conclusively proven that the presence of glucose exerts not nearly so great an influence in retarding or preventing crystallization as is generally supposed to be the case.

For the reasons which have been outlined, it has been decided to hereafter ignore the glucose, and base selection upon the following characters: *high purity*, *high sucrose*, *low non-sugar*.

PRELIMINARY SELECTION BY THE SPINDLE.

When selecting the best individual canes of any variety of sorghum for the purpose of preserving seed of high quality, it has been the practice, both at Sterling and at Calumet, to cut from the apparently ripest and healthiest stalks a convenient quantity for the day's analyses, and to grind these, one by one, placing each seed-head with its corresponding juice sample; then, floating a Brix spindle in each juice, to select all samples giving a reading above some arbitrary standard for further examination, and preserving the heads belonging with these, to reject the balance as of inferior worth. It is generally true that with normal and healthy canes this method retains the samples with highest sucrose content, but the question has been raised whether, in thus rejecting juices with lower solids and sucrose, we do not often lose some possessing superior purity. The result of many analyses indicates that a considerable number of juices of high purity, but with a low degree Brix, are excluded and the seed lost, while many with high degree Brix, but low purity, are retained for further and useless work by this procedure. For example, among a number of canes examined with reference to this point, on September 1, 1890, the juice from each cane was analyzed, irrespective of the spindle reading. The lowest Brix reading obtained was 17.68°; the purity of the juice giving this was found to be 75.22 per cent. The highest Brix, 20.28°, was that of a juice which, upon analysis, showed but 75.69 per cent. Preliminary selection based on the degree Brix would have rejected the former and retained the latter, though the difference in purity was trifling, and such instances might be indefinitely multiplied. But since the term "purity" expresses the ratio *per cent.* of sucrose to

the total solids of a juice or other sugar product, then given two juices with equal purity, but one of high and the other of low per cent. solids (Brix), the former would in any case be the one finally chosen, for it contains more sucrose for an equal quantity of cane or juice, with the collateral advantage of less water to be evaporated.

Quite often juices with the same per cent. solids are found to vary from one to two or more per cent. in purity, and thus no reliable prediction can be made of the latter from the Brix indication, though, in general, purity, within rather uncertain limits, is in direct proportion to the amount of solids. The ordinary spindle selection is in the long run not far astray, and is a fair, though rough, means of obtaining seed of good quality when the knowledge or appliances for more complete polariscopic analysis is not at hand. Though by use of the spindle we may lose some few desirable canes in the preliminary selection, yet there is avoided the waste of time and the useless analytical work which otherwise would be incurred.

TOTAL SOLIDS BY THE BRIX SPINDLE AND BY DRYING.

Purity has been calculated as usual in the work of the Calumet laboratory on the per cent. solids obtained by correcting for temperature the reading of the Brix spindle. To find approximately the error of this method, some forty determinations of the actual solids of the juice were made by drying samples (2 grammes) of juice to constant weight in the water-oven at 98° C., the sample being contained in a flat, shallow platinum dish, and evaporated without the use of sand or other accessory. The difference between the actual solids so determined and the corrected Brix was quite variable, but the latter was nearly always much too high, ranging from 0.1 to 0.8 and averaging 0.42. The inconstant amount of difference is chiefly due to the fact that the relative proportions of the various bodies not sucrose, with their varying specific gravity, are not always the same.

Were the purity calculated on the *true* solids, it would be uniformly and considerably higher, giving sorghum a better record than herein appears.

MARC.

Much time was devoted to estimation of marc, *i. e.*, solids of the cane not soluble in water, in several varieties of the 1890 sorghum, to determine which, if any of them, was least woody, and to compare the general result with sugar cane. It is regretted that no data could be obtained for 1889, as that season was very dry throughout the period of growth, and interesting comparison could be made with this year's figures, obtained in a wet time. The accepted opinion seems to be that canes are more or less woody as their growth is made in dry or in wet weather. The analyses given in Table X. indicate that the marc varies in an inverse ratio to the diameter of the stalk, and it seems probable that of two plantings of a variety of sorghum, one having wet and the other dry weather, the former, if of lower marc, will be so because of its larger canes rather than of any change in its juice-composition, for it appears to be very unlikely that any plant simply because excess of water is supplied to it, will take up of that element more than its normal functions require. Comparison of the average marc of Undendebule, the slenderest of the season's canes, with that of Ubehlana, the stockiest, will illustrate this influence of size.

Wide difference of fibre (marc) in samples from the same plot were frequent, owing to irregularity in the size of canes growing side by side. The necessity for using the healthiest canes for seed selection often prevented taking fair samples for marc determination, but the best was done that could be under the circumstances; and as all plots were cut into for seed selection to about the same degree, results are practically comparable, plot with plot.

The average percentage of marc on all the varieties examined was 12.73, about three per cent. higher than the commonly given figures for tropical cane.

TABLE X.

MARC.

Analysis Number.	VARIETY.	Date.	Days From Planting.	Per Cent. Marc.	Per Cent. Juice.	REMARKS.
1	Early Orange.	July 19.	117	13.78	86.22	
2	Early Orange.	July 19.	117	12.84	87.16	
42	Early Orange.	Aug. 6.	135	11.54	88.46	
43	Early Orange.	Aug. 6.	135	11.31	88.69	
45	Early Orange.	Aug. 6.	135	11.67	88.33	
47	Early Orange.	Aug. 6.	135	12.99	87.01	
69	Early Orange.	Aug. 12.	109	13.37	86.63	
104	Early Orange.	Aug. 22.	119	11.22	88.78	
122	Early Orange.	Aug. 26.	123	10.65	89.35	
136	Early Orange.	Aug. 29.	126	12.64	87.36	
147	Early Orange.	Sept. 2.	130	14.99	85.01	
171a	Early Orange.	Sept. 16.	122	11.34	88.66	
	—Average of	Early	Orange .	12.36	87.64	
4	Link's Hybrid.	July 21.	119	13.92	86.08	
84	Link's Hybrid.	Aug. 18.	147	15.31	84.69	
115	Link's Hybrid.	Aug. 24.	121	10.77	89.23	
123	Link's Hybrid.	Aug. 26.	123	11.75	88.25	
137	Link's Hybrid.	Aug. 29.	126	12.53	87.47	
148	Link's Hybrid.	Sept. 2.	130	12.79	87.21	
	—Average of	Link's	Hybrid .	12.85	87.15	
75	Undendebule.	Aug. 15.	144	17.27	82.73	
85	Undendebule.	Aug. 19.	148	14.30	85.70	
106	Undendebule.	Aug. 22.	119	13.16	86.84	
124	Undendebule.	Aug. 26.	123	11.91	88.09	
138	Undendebule.	Aug. 29.	126	13.66	86.34	
149	Undendebule.	Sept. 2.	130	11.09	88.91	
	—Average of	Undende	bule . .	13.57	86.43	Smallest canes: compare with Ubehlana.
76	Ubehlana.	Aug. 15.	144	10.65	89.35	
102	Ubehlana.	Aug. 21.	150	11.32	88.68	
	—Average of	Ubeh	lana . .	10.99	89.01	Largest canes: compare with Undendebule.
20	Colman Cane.	July 28.	126	12.15	87.85	
63	Colman Cane.	Aug. 11.	140	13.17	86.83	
	—Average of	Colman	Cane . .	12.66	87.34	
55	Red Liberian.	Aug. 10.	139	10.96	89.04	From Plot No. 5A.
53	Red Liberian.	Aug. 10.	Not known	16.54	83.46	Field sorghum (forage crop).
98	Planter's Friend.	Aug. 20.	149	13.19	86.81	
	Total average		. . . . .	12.73	87.27	

STARCH AND OTHER NON-SUGARS.

To the bodies neither sucrose nor glucose, which form a part of the solids in the juice of sorghum cane and other sugar plants, the name "non-sugar" may be appropriately given, their percentage, of course, being found by subtracting the sum of sucrose and glu-

cose from the total solids. The presence in large proportion of these non-sugars is perhaps the most discouraging obstacle, from the chemical standpoint, to the economic extraction of the contained sugar from sorghum juice, for these, consisting as they do chiefly of gum-like substances and organic acids, act chemically by restraining from crystallization and inverting the sucrose, as well as mechanically by making proper purging of the *masse cuites* very difficult.

The *inorganic* portion of non-sugar, which consists of silica, potash and lime salts, etc., is not very great and may be disregarded; but the *organic* portion is very harmful, and a successful method for its removal by clarification is yet to be discovered.* Before intelligent investigation in this direction is practicable, knowledge must be acquired of the chemical nature and properties of the bodies with which we have to deal. Many analyses have been made at different times and in various places, through which many of the constituents of sorghum juice have been separated and recognized, but very many are still imperfectly or not at all identified. Among other organic substances, the presence of malic, tartaric and citric acids, together with starch, has been fully established, the two former and the latter of these existing in considerable quantity. Tartaric and citric acids are eliminated quite perfectly by lime as employed in ordinary clarification, and malic acid perhaps as well. Of all the bodies mentioned, however, starch is without doubt the worst in its effects. In the mill-juice of all varieties of sorghum examined in this laboratory, this substance has been found in quantity, occurring as a grayish-white, creamy sediment at the bottom of vessels in which raw juice has stood aside for an hour or so. By washing and decanting, about five grammes of pure white starch were on one occasion obtained from about as many litres of juice, a very considerable part of the original amount being lost in the effort to separate the associated impurities.

All milling processes will extract starch from sorghum cane, and the more perfect the mill, the greater the amount of it, for it exists

* NOTE.—Since the foregoing was written, a method has been proposed by Dr. H. W. Wiley, of the United States Department of Agriculture, for the removal of starch and gum from sorghum juices by a clarification in which precipitation with alcohol is the important feature. This may soon be tried on an industrial scale, and its success means a new impulse to the sorghum sugar industry.

in the stalk in the condition of minute imbedded granules, and in proportion as the cane is more thoroughly disintegrated, more starch-grains are freed to be washed out by the juice. When once introduced, starch can not be separated from the raw juice except possibly by filtration (scarcely practicable), or by allowing the juice to stand until the starch has subsided, which latter method would render loss by fermentation certain.

Starch, suspended in the raw mill-juice as exceedingly fine, insoluble granules, becomes *soluble* as soon as the temperature is raised to 50° C. (167° F.) during the ensuing clarification, for at this temperature the granules swell, their envelopes rupture and the contents are discharged as a pasty mass which afterward remains in solution at all common temperatures, and no means for its precipitation is known which can be employed in the sugarhouse. Part of the now soluble starch, perhaps all of it, is converted to *dextrin* by the lime of the clarifier and by the continued boiling of subsequent processes, showing itself finally in the centrifugal as a heavy, clinging gum, which obstructs the meshes of the wire-cloth and renders purging (separation of the molasses) almost and often altogether impossible.

Diffusion has therefore been found the best means of extracting the juice from sorghum cane, quite aside from the superior completeness of this process over milling. The process of comminuting mechanically ruptures fewer of the vegetable cells and therefore frees fewer of the included starch granules than mill crushing, and what remains is enclosed by unbroken cellular tissue: starch, being colloidal or gum-like, is not osmosed by water passed over the chips. Again, such starch grains as are freed to be carried by the current of juice from one cell to the next, through the battery, will be partially filtered out by entanglement among the chips through which it passes, and what passes on from one cell will thus be more or less completely removed in the next, and so on, a juice finally leaving the battery which contains but little more starch than what is washed from the chips of the last cell in the series.

But in diffusion as ordinarily employed with cane, an element is introduced which has not been taken into account in the previous paragraph—that is to say, the *temperature* at which the battery is operated; for, as has been said, the insoluble granular form of starch changes and becomes pasty and soluble at 50° C., not to be afterward removed by means of filtration. With the

starch which is still enclosed in the cellular structure of the chips, this is not so important; but when it is realized that in each cell of chips there exist cut and torn surfaces aggregating many thousand square feet in extent, studded with half-imbedded starch grains, it is plain that, as soon as the temperature mentioned is reached, there become soluble, and thus go into the juice immediately, not only the already suspended grains, but immense numbers which would otherwise not be dislodged at all from the chips—all this gum thenceforth not to be removed in any economical manner yet known. Diffusion at a lower temperature, with larger cells, finer chips and higher dilution, could be practiced without such conversion becoming serious, and at little loss of time.

It has been claimed that purer juices are obtained by hot than by cold diffusion, this being attributed to the fact that high temperatures coagulate, and thus cause the chips to entangle and retain the albuminoids present. These bodies, however, it seems not essential to leave behind in the battery, for they can be removed by the succeeding clarification. It is surely worse to have a juice with (say) purity of 75 per cent. in which the non-sugars are gums, than one with a purity perhaps 3 per cent. lower, but with non-sugars consisting chiefly of albuminoid bodies amenable to the ordinary lime clarification.

CONCLUSIONS.

From the two years' cultural experiments, made during seasons of diametrically opposite character, it seems reasonable to conclude that: (1.) Several varieties exist which, from both the agricultural and manufacturing points of view, already promise to answer the requirements of a profitable supplemental sugar crop on the tropical cane plantations of Louisiana, and that, therefore, it is wise that the experiment should be continued. (2.) The adverse climatic conditions of 1890 considered, progress has been made in the improvement of several of the better varieties by seed selection and otherwise, which, it is fair to anticipate, will become more pronounced with further effort under more favorable conditions. (3.) The principal difficulties attending the improvement of varieties in Louisiana by seed selections are (*a*) the difficulty of protecting seed from insects, sprouting, etc.: (*b*) the considerable cost of

the analytical work which such selection involves. (4.) Diffusion or some analogous process is absolutely necessary, instead of the cane-mill, for the extraction of its juices when the latter are to be worked for sugar. (5.) The extraction should be carried on at a temperature below 50° C. The mare is too high to permit of reasonably good extractive results, even from the repeated crushings of the Calumet 8-roller mill, and juices so secured will fail to produce sugar in paying quantities, owing to the presence of starch, gums, etc., consequent upon the grinding process. (6.) Improvement in the purity of the juices is of more economic importance for the present than any mere increase of the sugar content without such increased purity. (7.) Seed-selection work should be confined as strictly as may be to the best varieties already possessed, and propagation from single heads followed without deviation.

The conclusion that any variety of the sorghum cane promises to become an economic source of commercial sugar, especially in Louisiana, may not appear warranted by the repeated failures to produce sugar from it with profit elsewhere. In the following table, No. XI., is given, to a close approximation, the average composition of Calumet sorghum juice for several leading varieties, for the years 1889 and 1890:

TABLE XI.

Summary of all average analyses of six varieties (1889–90).

VARIETY.	Solids.	Sucrose.	Purity.	Glucose.	Non-sugar.
Early Orange	18.50	13.33	72.05	1.93	3.24
Late Orange	18.23	13.43	73.67	2.24	2.56
Improved Orange	19.17	14.40	75.12	2.12	2.65
Link's Hybrid	19.75	14.27	72.25	1.10	4.38
Colman Cane	20.15	15.47	76.77	.63	4.05
Undendebule	19.56	14.63	74.79	.78	4.15
Average	19.23	14.26	74.15	1.47	3.50

A comparison of this table with the next, which gives, approximately, the average analysis of sorghum juices actually worked for sugar at Northern factories, does much to explain away past manufacturing failures elsewhere and to strengthen the hopeful conclusion which the work here appears for the present to sanction, although the uncertainty of any conclusion, based upon the comparison of small plots with extensive fields, is recognized.

The conclusion is not yet warranted that sorghum, as a source of sugar, can ever attain in Louisiana the excellence possible to it in Kansas, or that it can ever rival the tropical cane now grown in the former State. A comparison of the analyses and actually-obtained yields, recorded in Tables XI. and XII., indicates the necessity for vast improvement in the purity, even of Calumet sorghum juices, as exhibited in Table XI., before these can claim equality with tropical cane juices. The sorghum is at further disadvantage owing to the quality of the impurities contained in its juices, in the lighter tonnage produced on given areas of land, and in its smaller percentage of contained juice. The superior amount of sucrose in its juice counts for nothing so long as it remains unavailable in manufacture.

But although it is not likely soon to become intrinsically so valuable a source of commercial sugar to the Louisiana planter as his present cane, and although it may never attain the excellence in Louisiana possible to it in Kansas, it must not be forgotten that it need not become such to be equally profitable. Fixed charges on the manufacturing plant and farm equipment, such as interest, depreciation, taxes and insurance, salaries of overseers, clerks, engineers, chemists and others employed by the year and the like, all now and hereafter necessary to the production of sugar from the tropical cane, will continue to be charged to this only. Free from these, which amount to perhaps one-third of the total expense account on the larger plantations, sorghum enters the cane fields at an immense advantage. To this must be added the advantage accruing from a propagation *by seed* over that *by cuttings*, which should reduce the expenses of planting alone by from fifteen to eighteen dollars per acre.

This report may fitly close with the summary presented in Table XIII., which shows the analyses and yields of sugar, per ton, obtained with Louisiana tropical cane juices, from 1884 to 1890, inclusive, as given in various published reports, and the comparison of this with Table XII. will prove interesting. Both these tables are the result of laborious and careful reviews made by Mr. W. J. Thompson, whose deep interest and material achievements in advancing the sugar industry are well known.

TAB

Average Campaign Analyses of Louisiana

Year.	FACTORY.	Solids.	Sucrose.	Glucose.	Non-sugar.	Purity.	REFEREN
1884	Magnolia	16.15	12.62	0.87	2.66	78.14	Bul. No. 5, U. S. Dept. Ag
1885	Magnolia	15.08	12.11	1.02	2.67	76.64	Bul. No. 11, U. S. Dept. Ag
1886	Magnolia	16.15	13.51	0.59	2.05	83.56	Bul. No. 15, U. S. Dept. Ag
1887	Magnolia	16.37	13.69	0.77	1.91	83.48	Bul. No. 18, U. S. Dept. Ag
1887	Magnolia, First Run	15.03	12.26	0.99	1.78	81.57	Bul. No. 17, U. S. Dept. Ag
1887	Magnolia, Second Run	14.98	12.61	0.88	1.49	84.18	Bul. No. 17, U. S. Dept. Ag
1887	Magnolia, Third Run	13.88	11.53	0.78	1.57	83.07	Bul. No. 17, U. S. Dept. Ag
1887	Magnolia, Fourth Run	16.79	14.60	0.49	1.70	86.96	Bul. No. 17, U. S. Dept. Ag
1887	Magnolia, Fifth Run	16.66	13.98	0.70	1.98	83.91	Bul. No. 17, U. S. Dept. Ag
1887	Evan Hall	14.54	11.50	1.18	1.86	79.09	Report L. A. Becnel, 1887,
1887	Belle Alliance	14.21	11.08	1.33	1.80	77.29	Report L. A. Becnel, 1887,
1888	Magnolia	16.40	14.10	0.56	1.74	85.97	Bul. No. 21, U. S. Dept. Ag
1888	Magnolia	17.50	15.30	0.62	1.58	87.40	Bul. No. 21, U. S. Dept. Ag
1888	Des Lignes (last half of campaign)	15.80	13.84	0.95	1.01	87.60	Bul. No. 22, U. S. Dept. Ag
1888	Calumet, Rattoon Crop	16.32	13.78	0.97	1.57	84.43	Bul. No. 23, U. S. Dept. Ag
1888	Calumet, Plant Crop	16.39	13.89	0.95	1.55	84.75	Bul. No. 23, U. S. Dept. Ag
							W. J. Thompson
1888	Evan Hall	15.07	11.79	1.69	1.59	78.23	Report L. A. Becnel, chemi
1888	Belle Alliance	16.30	13.33	1.67	1.30	81.78	Report L. A. Becnel, chemi
1888	Souvenir	15.63	12.52	1.41	1.70	80.10	Report L. A. Becnel, chemi
1889	Magnolia	15.60	12.73	0.96	1.91	81.60	G. L. Spencer, *La. Planter*,
1889	Calumet, Rattoon Crop	16.39	13.46	1.34	1.59	82.10	Report Hubert Edson, chen
1889	Calumet, Plant Crop	15.52	12.84	1.00	1.68	82.70	Report Hubert Edson, chen
1889	Evan Hall	15.89	12.46	1.76	1.67	78.48	Report L. A. Becnel, chemi
1889	Belle Alliance	16.17	12.94	1.96	1.27	80.02	Report L. A. Becnel, chemi
1889	Souvenir	15.43	12.68	1.58	1.17	81.93	Report L. A. Becnel, chemi
1889	New Hope	16.27	13.23	1.69	1.35	81.36	Report L. A. Becnel, chemi
1889	Belle Terre	17.68	14.27	1.72	1.69	80.69	Report L. A. Becnel, chemi
1889	Palo Alto	15.40	12.37	1.80	1.23	80.34	Report L. A. Becnel, chemi
1890	Calumet, Total Crop	15.61	12.40	1.43	1.78	79.45	Report Hubert Edson, chen
1890	Caffery Central, Total Crop	16.21	13.50	1.57	1.14	83.29	Report L. Von Tresckow, c
1890	Willswood, Messrs. Schmidt & Ziegler	15.18	12.48	1.30	1.40	82.21	M. Bird, chemist, *La. Plan*
	Average, 1884 to 1890, inclusive	15.85	13.02	1.18	1.65	82.14	

TABLE XII.

Average Campaign Analyses of Sorghum Juices Worked at Sorghum Sugar Factories, Compiled from Various Published Reports.

Year.	FACTORY.	Solids.	Sucrose.	Glucose.	Non-sugar.	Exponent.	REFERENCES.	Extraction Apparatus.	Yield per Ton. Cane, lbs.	REMARKS.
1882	Rio Grande, N. J.	13.20	11.11	. . .	. . .	84.17	Bul. No. 3, U. S. Dept. Agrc., p. 60, H. A. Hughes	Mill of 3 rolls		
1883	Washington, D. C.	14.81	8.58	4.08	2.15	60.40	Bul. No. 2, U. S. Dept. Agrc., p. 32	Diffusion		Experiments by Dr. H. W. Wiley.
1883	Rio Grande, N. J.	13.60	9.75	. . .	. . .	71.69	Bul. No. 3, U. S. Dept. Agrc., p. 60	Double mill macerat'n	41.60	
1883	Champaign, Ill.	14.50	7.78	4.76	1.96	53.66	Bul. No. 3, U. S. Dept. Agrc., p. 62	Double mill		Cane injured by frost.
1883	Hutchinson, Kas.	15.69	11.08	3.34	1.27	70.62	Bul. No. 3, U. S. Dept. Agrc., p. 65	Single 3-roll mill		
1884	Hutchinson, Kas.	15.30	10.50	4.10	0.70	68.63	Bul. No. 5, U. S. Dept. Agrc., p. 166	Single 3-roll mill	47.00	Yield stated is that secured subsequent to September 5th.
1885	Franklin Sugar Co., Ottawa, Kas.	15.07	9.23	3.04	2.87	61.25	Bul. No. 6, U. S. Dept. Agrc., p. 15	Double mill		
1885	Ottawa, Kas. First run	15.70	10.25	2.90	2.55	65.29	Bul. No. 6, U. S. Dept. Agrc., p. 8	Diffusion	95.00	Experiments by Dr. Wiley, two days following ice.
1885	Ottawa, Kas. Second run	14.62	9.06	2.69	2.87	61.97	Bul. No. 6, U. S. Dept. Agrc., p. 10	Diffusion		Experiments by Dr. Wiley, seven days following ice.
1885	Rio Grande, N. J.	12.99	8.93	. .	. . .	68.75	Bul. No. 18, U. S. Dept. Agrc., p. 82	Mill, bagasse diffused	37.87	Yield based on field cane, worked without topping or cleaning.
1886	Fort Scott, Kas. Before Oct. 1st	17.56	10.49	4.01	3.06	59.73	Bul. No. 14, U. S. Dept. Agrc., p. 15	Diffusion		Based on samples of whole cane passed thro' experimental mill.
1886	Fort Scott, Kas. After Sept. 30th	16.60	8.70	4.15	3.75	52.41	Bul. No. 14, U. S. Dept. Agrc., p. 16	Diffusion		Canes left too long cut. Experiments by Dr. H. W. Wiley.
1886	Fort Scott, Kas. Before Oct. 1st	15.63	9.34	3.57	2.72	59.76	Bul. No. 14, U. S. Dept. Agrc., p. 31	Diffusion	21.6	Experiments by Dr. Wiley, based on fresh chip samples passed through experimental mill. Canes left too long cut. Analyses of material actually worked.
1886	Fort Scott, Kas. After Sept. 30th	14.77	7.74	3.79	3.24	52.40		Diffusion	See Bul. No. 18, U. S. Dep. Agrc., p. 126.	
1886	Fort Scott, Kas. After Oct. 14th	13.17	6.48	3.31	3.38	49.20		Diffusion		
1886	Fort Scott, Kas. Means of last three	14.56	7.85	3.56	3.15	53.90		Diffusion		
1887	Fort Scott, Kas.	16.14	9.54	3.40	3.20	59.11	Bul. No. 17, U. S. Dept. Agrc., p. 15; Bul. No. 18, U. S. Dept. Agrc., pp. 8, 127	Diffusion		
1887	Rio Grande, N. J.	14.02	8.98	3.24	1.80	64.05	Bul. No. 17, U. S. Dept. Agrc., p. 72; Bul. No. 18, U. S. Dept. Agrc., pp. 21, 127	Hughes' open diffusion		
1888	Rio Grande, N. J.	13.99	8.23	. . .	. . .	58.50	Bul. No. 20, U. S. Dept. Agrc., p. 45	Hughes' open diffusion		
1888	Conway Springs, Kas.	19.39	12.42	2.61	4.36	63.84	Bul. No. 20, U. S. Dept. Agrc., p. 85	Diffusion	52.80	Yield based on clean cane. Bul. No. 20, p. 82.
1888	Douglas, Kas.	16.89	9.88	3.01	4.00	58.34	Bul. No. 20, U. S. Dept. Agrc., p. 99	Hughes' open diffusion	26.20	Yield based on clean cane. Bul. No. 20, p. 97.
1889	Conway Springs, Kas.	18.33	11.68	1.70	4.95	63.72	Bul. No. 26, U. S. Dept. Agrc., p. 70	Diffusion		
1889	Attica, Kas.	17.03	11.59	1.72	3.72	68.06	Bul. No. 26, U. S. Dept. Agrc., p. 75	Diffusion	99.50	Yield based on clean cane. Bul. No. 26, p. 74. Two sugars. Seconds estimated.
1889	Medicine Lodge, Kas.	16.46	10.44	2.24	3.78	63.66	Bul. No. 26, U. S. Dept. Agrc., p. 77	Diffusion		
1889	Meade, Kas.	18.02	10.61	3.85	3.56	58.88	Bul. No. 26, U. S. Dept. Agrc., p. 80	Diffusion		
1889	Ness City, Kas.	16.58	6.34	5.51	4.73	38.24	Bul. No. 26, U. S. Dept. Agrc., p. 82	Diffusion		
	Average, 1884 to 1889, inclusive	15.56	9.87	3.39	3.08	61.16				

TABLE XIII.

Average Campaign Analyses of Louisiana Cane Juice, Compiled From Various Published Reports.

Year.	FACTORY.	Solids.	Sucrose.	Glucose.	Non-sugar.	Purity.	REFERENCES.	Extraction Apparatus.	Yield per Ton—lbs.	REMARKS.
1884	Magnolia	16.15	12.62	0.87	2.66	78.14	Bul. No. 5, U. S. Dept. Agrc., p. 46	Shredder and 5-roll mill.	158.42	Boiled three sugars.
1885	Magnolia	15.08	12.11	1.02	2.67	76.64	Bul. No. 11, U. S. Dept. Agrc., p. 12	Shredder and 5-roll mill.	148.75	Boiled two sugars only.
1886	Magnolia	16.15	13.51	0.59	2.05	83.56	Bul. No. 15, U. S. Dept. Agrc., p. 9	Shredder and 5-roll mill.	161.00	Boiled two sugars only.
1887	Magnolia	16.37	13.69	0.77	1.91	83.48	Bul. No. 18, U. S. Dept. Agrc., pp. 31, 47	Shredder and 5-roll mill.	179.93	Boiled three sugars.
1887	Magnolia, First Run	15.03	12.26	0.99	1.78	81.57	Bul. No. 17, U. S. Dept. Agrc., p. 83	Diffusion	201.20	Thirds estimated.
1887	Magnolia, Second Run	14.98	12.61	0.88	1.49	84.18	Bul. No. 17, U. S. Dept. Agrc., p. 84	Diffusion	188.00	Thirds estimated.
1887	Magnolia, Third Run	13.88	11.53	0.78	1.57	83.07	Bul. No. 17, U. S. Dept. Agrc., p. 86	Diffusion	Unknown.	
1887	Magnolia, Fourth Run	16.79	14.60	0.49	1.70	86.96	Bul. No. 17, U. S. Dept. Agrc., p. 87	Diffusion	230.00	Three sugars. *Actual weights.*
1887	Magnolia, Fifth Run	16.66	13.98	0.70	1.98	83.91	Bul. No. 17, U. S. Dept. Agrc., p. 88	Diffusion	215.80	Three sugars. All wagon sugars estimated.
1887	Evan Hall	14.54	11.50	1.18	1.86	79.09	Report L. A. Becnel, 1887, chemist, p. 6	5-roll mill	123.94	Boiled two sugars only.
1887	Belle Alliance	14.21	11.08	1.33	1.80	77.29	Report L. A. Becnel, 1887, chemist, p. 6	5-roll mill	124.10	Boiled two sugars only.
1888	Magnolia	16.40	14.10	0.56	1.74	85.97	Bul. No. 21, U. S. Dept. Agrc., pp. 28, 30	Diffusion	222.00	Boiled four sugars.
1888	Magnolia	17.50	15.30	0.62	1.58	87.40	Bul. No. 21, U. S. Dept. Agrc., p. 60	Shredder and 5-roll mill.	167.90	Boiled four sugars.
1888	Des Lignes (last half of campaign)	15.80	13.84	0.95	1.01	87.60	Bul. No. 22, U. S. Dept. Agrc., p. 19	Two 3-roll mills, tandem	150.10	Boiled three sugars. Macerated at times between mills.
1888	Calumet, Rattoon Crop	16.32	13.78	0.97	1.57	84.43	Bul. No. 23, U. S. Dept. Agrc., p. 26	5-roll mill	192.39	Boiled three sugars. No maceration.
1888	Calumet, Plant Crop	16.39	13.89	0.95	1.55	84.75	Bul. No. 23, U. S. Dept. Agrc., compiled from, by W. J. Thompson	5-roll mill, maceration part of time	214.67	Boiled three sugars. Macerated at times between mills.
1888	Evan Hall	15.07	11.79	1.69	1.59	78.23	Report L. A. Becnel, chemist, 1888, pp. 6, 21	5-roll mill	144.32	Boiled three sugars. Macerated at times between mills.
1888	Belle Alliance	16.30	13.33	1.67	1.30	81.78	Report L. A. Becnel, chemist, 1888, pp. 6, 21	5-roll mill	164.27	Boiled three sugars. Macerated at times between mills.
1888	Souvenir	15.63	12.52	1.41	1.70	80.10	Report L. A. Becnel, chemist, 1888, pp. 6, 21	5-roll mill	130.13	Boiled two sugars only.
1889	Magnolia	15.60	12.73	0.96	1.91	81.60	G. L. Spencer, *La. Planter*, May 17, 1890	Diffusion	213.09	Boiled three sugars. Thirds estimated at 20 lbs.
1889	Calumet, Rattoon Crop	16.39	13.46	1.34	1.59	82.10	Report Hubert Edson, chemist, 1889, p. 14	8-roll mill	183.74	Boiled two sugars only. Macerated between back mills.
1889	Calumet, Plant Crop	15.52	12.84	1.00	1.68	82.70	Report Hubert Edson, chemist, 1889, p. 16	8-roll mill	184.18	Boiled two sugars only. Macerated between back mills.
1889	Evan Hall	15.89	12.46	1.76	1.67	78.48	Report L. A. Becnel, chemist, 1889, p. 7	5-roll mill	145.05	Boiled portion of crop for third sugars. Macerated bet. mills.
1889	Belle Alliance	16.17	12.94	1.96	1.27	80.02	Report L. A. Becnel, chemist, 1889, p. 10	5-roll mill	163.00	Boiled portion of crop for third sugars. Macerated.
1889	Souvenir	15.43	12.68	1.58	1.17	81.93	Report L. A. Becnel, chemist, 1889, p. 12	5-roll mill	154.87	Boiled portion of crop for third sugars.
1889	New Hope	16.27	13.23	1.69	1.35	81.36	Report L. A. Becnel, chemist, 1889, p. 14	5-roll mill	154.68	Boiled two sugars only.
1889	Belle Terre	17.68	14.27	1.72	1.69	80.69	Report L. A. Becnel, chemist, 1889, p. 16	5-roll mill	164.42	Boiled three sugars.
1889	Palo Alto	15.40	12.37	1.80	1.23	80.34	Report L. A. Becnel, chemist, 1889, p. 18	5-roll mill	145.26	Boiled three sugars.
1890	Calumet, Total Crop	15.61	12.40	1.43	1.78	79.45	Report Hubert Edson, chemist, 1890	8-roll mill	181.62	Third sugars estimated. Maceration between back mills.
1890	Caffery Central, Total Crop	16.21	13.50	1.57	1.14	83.29	Report L. Von Tresckow, chemist, 1890, p. 17	7-roll mill	190.88	Third sugars estimated. Double maceration.
1890	Willswood, Messrs. Schmidt & Ziegler	15.18	12.48	1.30	1.40	82.21	M. Bird, chemist, *La. Planter*, March 14, 1891	7-roll mill	162.40	Maceration at first mill. Two sugars, actual weights.
	Average, 1884 to 1890, inclusive	15.85	13.02	1.18	1.65	82.14				

The conclusion is not yet warranted that sorghum, as a source of sugar, can ever attain in Louisiana the excellence possible to

XIII.

Compiled From Various Published Reports.

	Extraction Apparatus.	Yield per Ton—lbs.	REMARKS.
. . . .	Shredder and 5-roll mill.	158.42	Boiled three sugars.
. . . .	Shredder and 5-roll mill.	148.75	Boiled two sugars only.
. . . .	Shredder and 5-roll mill.	161.00	Boiled two sugars only.
. . . .	Shredder and 5-roll mill.	179.93	Boiled three sugars.
. . . .	Diffusion	201.20	Thirds estimated.
. . . .	Diffusion	188.00	Thirds estimated.
. . . .	Diffusion	Unknown.	
. . . .	Diffusion	230.00	Three sugars. *Actual weights.*
. . . .	Diffusion	213.80	Three sugars. All wagon sugars estimated.
. . . .	5-roll mill	123.94	Boiled two sugars only.
. . . .	5-roll mill	124.10	Boiled two sugars only.
. . . .	Diffusion	222.00	Boiled four sugars.
. . . .	Shredder and 5-roll mill.	167.90	Boiled four sugars.
. . . .	Two 3-roll mills, tandem	150.40	Boiled three sugars. Macerated at times between mills.
. . . .	5-roll mill	192.39	Boiled three sugars. No maceration.
ım, by	5-roll mill, maceration part of time	214.67	Boiled three sugars. Macerated at times between mills.
1 . . .	5-roll mill	144.32	Boiled three sugars. Macerated at times between mills.
1 . . .	5-roll mill	164.27	Boiled three sugars. Macerated at times between mills.
1 . . .	5-roll mill	130.13	Boiled two sugars only.
. . .	Diffusion	213.09	Boiled three sugars. Thirds estimated at 20 lbs.
. . . .	8-roll mill	183.74	Boiled two sugars only. Macerated between back mills.
. . . .	8-roll mill	184.18	Boiled two sugars only. Macerated between back mills.
. . . .	5-roll mill	145.05	Boiled portion of crop for third sugars. Macerated bet. mills.
. . . .	5-roll mill	163.00	Boiled portion of crop for third sugars. Macerated.
. . . .	5-roll mill	154.87	Boiled portion of crop for third sugars.
. . . .	5-roll mill	154.68	Boiled two sugars only.
. . . .	5-roll mill	164.42	Boiled three sugars.
. . . .	5-roll mill	145.26	Boiled three sugars.
. . . .	8-roll mill	184.62	Third sugars estimated. Maceration between back mills.
17 . . .	7-roll mill	190.88	Third sugars estimated. Double maceration.
01 . . .	7-roll mill	162.40	Maceration at first mill. Two sugars, actual weights.

Mr. W. D. Thompson,

ments in advancing the sugar industry are well known.

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